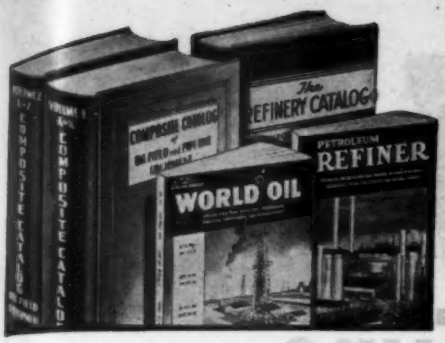

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for the refining-natural gasoline industry.

WORLD OIL (formerly The Oil Weekly)
and The COMPOSITE CATALOG
for the drilling-producing-pipe line industry

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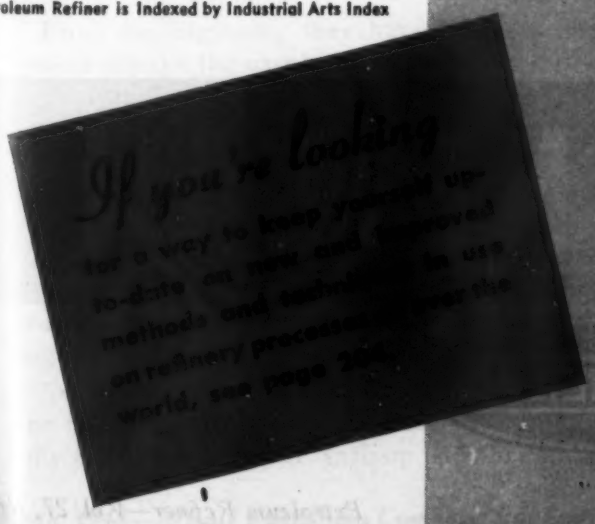

PETROLEUM REFINER

Specialized for the manufacturing division of the petroleum industry, refining, petrochemical processing, cycling and natural gasoline operations.

R. L. DUDLEY, President, Publisher A. L. BURNS, General Manager

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NEW

Instrument-Type
Ball Float Level Controllers

The ball float level controller still has a place in process control. Although level measurement by displacement has overshadowed the ball float type of measurement, there are many applications where, because of the nature of the liquid and/or operating conditions and/or physical limitations, measurement of level by ball float is the only practical solution.

Recognizing the many advanced features of the 12000 Series (displacement type) instruments, Mason-Neilan now offers you these features in combination with flange, chamber and shaft type ball float level controllers.

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Proportional-Reset Control
Remote Pneumatic Transmission
Duplex Control or Duplex Controller-Transmitter

These are the same mechanisms used on our 12000 Series displacement type level controllers.

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All assemblies are weatherproof, compact, rugged.

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VOLUME 27, NO. 3 MARCH, 1948

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

Mask or Blindfold?

R. L. DUDLEY

WE HAVE been reading lately that the "mask is off totalitarian Russia." But let's be fair. The mask is not off totalitarian Russia—the blindfold has merely slipped from the eyes of some of the people of the rest of the world.

Russia has never been, at any time within two-score years, more than she is today. With all their talk of "democracy" in which they indulged in 1945 and 1946 the powers that rule Russia with an iron hand have never relaxed for one moment the deathlike grip they have maintained upon their own people and the peoples of areas unfortunate enough to be within their power. They have never truly sought to help create a world in which all of us might live in peace. From the very beginning of the United Nations, that sad experiment in idealism in a world of realism, they have shown an inability to grasp the idea that peoples with divergent thoughts on personal liberty can live in peace on the Earth.

From the beginning they have mistaken (as is almost always the case) appeasement for cowardice. Never have they relented for one moment in their preachment that the western powers, including the U. S. were decadent . . . ready victims to vigorous Communistic thinking and action. Never have they shown the least appreciation of why the people of the U. S. twice went to war against Germany, but Nazi-like have thought that ruthlessness would win for them whatever their objectives might be.

No, in all fairness, Russia has not worn a mask. She has consistently proved to the world that the only difference between Naziism and Communism is that a hierarchy in Germany conceived and executed the one and that a similar hierarchy in Russia has conceived and is executing the other. As had been said a thousand times, the roads of the two ideologies lead to the same goal . . . personal power of an unlimited nature for the rulers and abject misery for those who are ruled.

But the time is rapidly shaping up when repetition of the words spoken a thousand times will not be enough.

Are we to forget what happened to the scrap steel we sent to Japan? Have we forgotten the American deaths made possible by the gasoline sent to the Japanese?

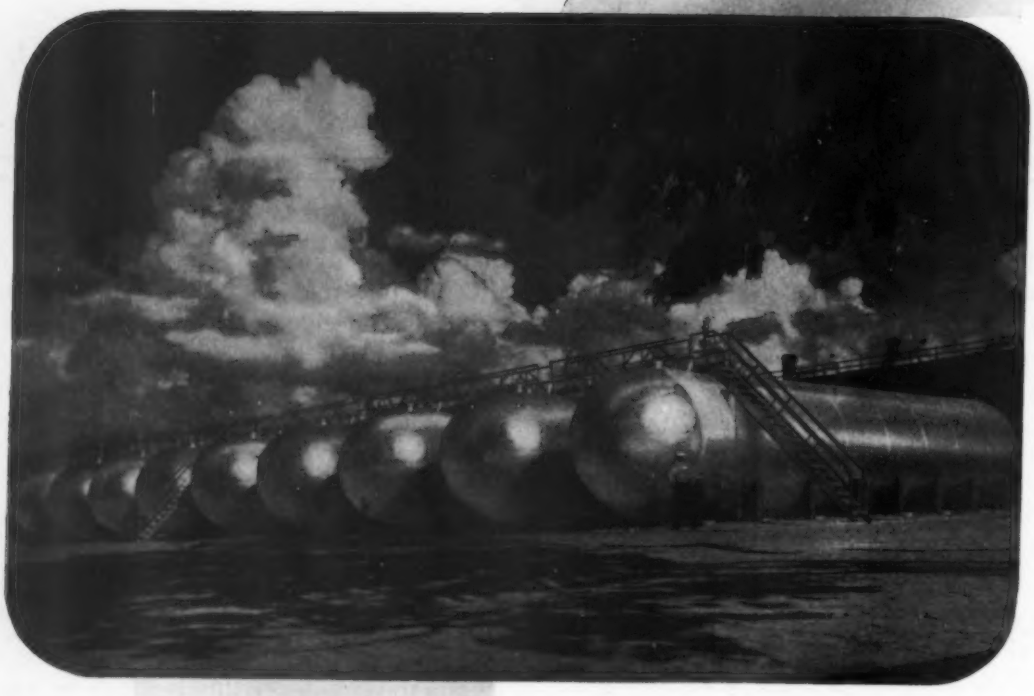
Russia today is feverishly building up her manufacturing power. There seems little hope that we shall not have to meet head-on that power before too long a time has passed. Why then allow a flow of American goods to continue to Russia and her satellites? Specifically, why continue to send oil country equipment to Russia? Oil, we all know, is vital to the successful prosecution of any war, be it of aggression or defense. Why help an enemy build up her oil production and supply?

If any manufacturer would think first of his business, let him think also of his sons, his grandsons, his nephews, the sons and loved ones of his friends, and let him think of his wife, his daughter and his granddaughters and the daughters of his friends, because the next war will be brought to our shores as surely as the sun will rise.

Now that the blindfold has slipped from the eyes of some who believed against reason, that Communism really meant brotherly love, who felt that appeasement was the proper policy, let us recognize those who still hold to a policy of appeasement for what they really are: fools or worse.

That recognition should be only a part of our

QUALITY IS 30 YEARS OLD AT BEAIRD . . . . .



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Pressure Bulk Storage Equipment

SINCE 1919
BEAIRD
SHREVEPORT

THE J. B. BEAIRD COMPANY, INC.

SHREVEPORT, LA.

self-defense. More is needed. A realistic appreciation for what is ahead should dictate a lot of things which ordinarily are repugnant to us. Few Americans of two generations ago would have favored universal military training, because there was no horde with which to deal. The example of German militarism under the Kaiser was so distasteful to the American way of thinking that we forgot the difference between defense and offense. But we should know better now. The blood of thousands of American boys, already sacrificed because the enemy thought we were not prepared and consequently ignored the price of aggression, is enough sacrifice to have paid.

Let us not forget the chaotic times of 1942 and late 1941 when we were almost defenseless, and the plans for the manufacture of the necessities of war about which we had heard so much (remember what was to have been M Day?) turned out to have been so many mouthings by inept politicians.

Let us not forget all of those things. Let us seek no war, but be ready to resist with all of the might within our being, any war thrust upon us.

Steel and Petroleum Supply

ACTION of a representative from Massachusetts in proposing a bill in the Congress which would apply a measure of government control on oil has raised strenuous objection on the part of many oil men, and justly so. We suspect that what the gentleman from Massachusetts desired most of all was more burning oil for his constituents, rather than to see his bill passed. But the problem of taking care of unprecedented demands for petroleum products is a real one, one which the industry cannot allow to drift along without a concerted effort to solve.

Much of our trouble, most of it at present, gets back to steel. The refineries are stepping up their expansion programs, but delivery of some products made of steel is holding up construction. Some close students think that the refining capacity of the country will have to be increased about ¼ million barrels a day over what it was the middle of last year, if we meet the demands of year after next. They think that this is a minimum figure. It is somewhat more than API indicates as the program of the industry.

Pipe for pipe lines is another important consideration. Steel for tankers is another. But topping the list, from the standpoint of peacetime demand and wartime urgency, is casing.

No meeting of interested parties likely will result in the increase of casing tonnage, but maladjustment of supply can be helped by proper cooperation. Threat of anti-trust action no doubt has caused many companies to be fearful of an industry-wide and industry-conducted plan for casing allocation, but there are signs that something will be done about it. We sincerely hope so because the oil industry will be the target of more legislation unless the people of this country are provided with necessary petroleum fuels.

Answer to the Rubber Subsidy Plea

A new synthetic rubber which may equal or surpass natural rubber in tire treads was recently reported by John P. Coe, vice president and general manager of United States Rubber Company's synthetic rubber division. He said that two large plants, one operated by U. S. Rubber at Borger, Texas, and another operated by Copolymer Corporation at Baton Rouge, La., are presently being equipped to manufacture the new rubber. This development is the result of research conducted by the synthetic rubber industry under the sponsorship of the Office of Rubber Reserve.

Preliminary data have indicated tire tread quality "substantially improved over anything achieved heretofore with natural rubber."

"If this improvement is established by service performance of tires over this year and next it is expected that such rubber will be used almost regardless of price," is the comment.

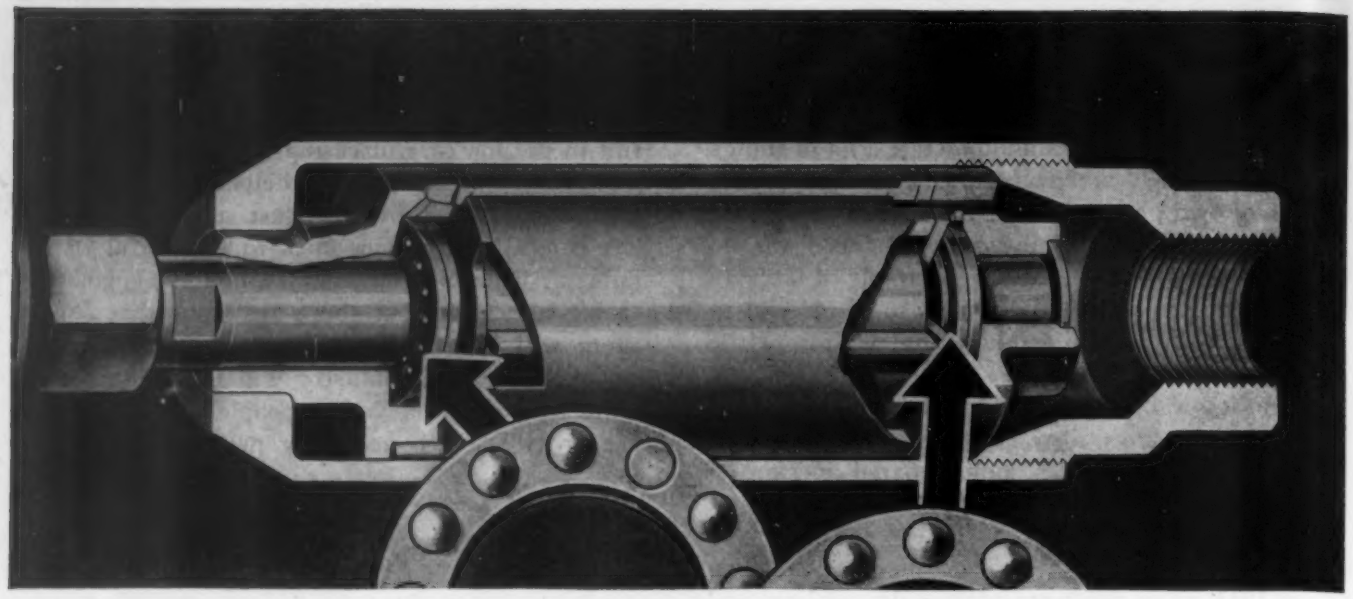
Tire rubber amounts some 25 to 35 percent of our consumption of natural rubber and this development may well serve to place GR-S synthetic rubber on an independent commercial basis.

Secret of the improvement is said to be a sharp reduction in the temperature of the reaction by which the rubber is produced from butadiene and styrene. Thse new rubber is made at temperatures between 0 and 40 degrees Fahrenheit instead of the usual 125 degrees.

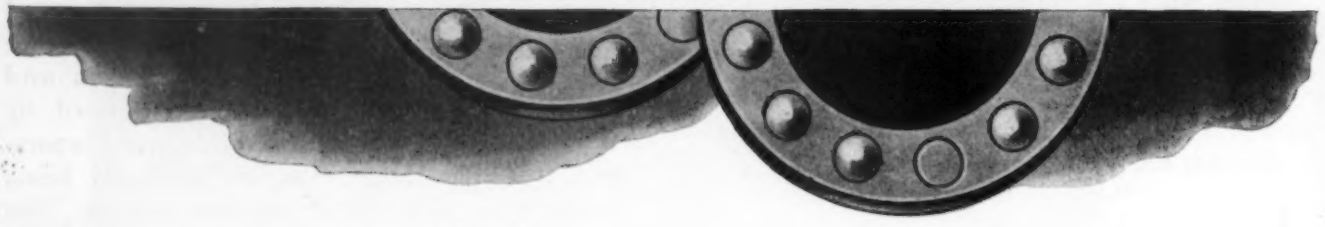
Coe concluded, "It is my position that synthetic rubber has now proved itself technologically, that it will continue to be manufactured and used on its own merits as a raw material required by industry."

All of which is certainly a more promising picture than the other route of synthetic rubber plants maintained largely as a government subsidy as a requirement of national defense.

* * *



How to keep CLEANOUTS ROLLING-*FAST*



The Lagonda 1100 Series cleaner with the 3300 Series, Swing-Frame, Long-Surface cutter head. This new Lagonda cutter head has the largest expansion ever obtained in a swing-frame head. It adds lots of extra cleaning range.

These two ball bearings pack extra power into a Lagonda 1100 Series motor. The front ball thrust bearing overcomes friction caused by the pull of the self-feeding cutter head. The rear ball thrust bearing kills the rotor drag caused by the operator shoving the cleaner into heavy coke. Together, these two ball bearings reduce friction losses 15% over ordinary motors with conventional thrust bearings.

Moreover, with this ball bearing design, thrust clearances can be maintained at a minimum, with no thrust plates to wear thin and let the power seep out. It all adds up to higher efficiency, extra power and faster, trouble-free cleaning — the kind every still needs for quick cleanouts.

Teamed with the correct Lagonda cutter head, the 1100 Series motor is your best bet for quicker cleanouts. The illustrated bulletin tells the whole story. Write for your copy today.

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DISTRICT OFFICES IN PRINCIPAL CITIES

Lagonda TUBE CLEANERS

Y-275

DAILY ACCIDENT REPORT

DATE March 12, 1947

CASE NO.	NAME	BADGE NO.	DEPARTMENT	OCCUPATION	FOREMAN	NATURE OF INJURY	LOST TIME	TIME OF ACC.	TIME OF REPORT	SENT TO M. D.	REMARKS
11	John J. Doe	1234	Maintenance	General Helper	Roe	left knee, swelling and contusion of	None	3-11-47 11:30 AM	8 AM	Yes	for X-Ray

Form of Daily Accident Report used by Republic Oil Refining Company

Management and Employes See Safety Program Pay Off

HOLLAND HOWELL
Chief Engineer, Republic Oil Refining Company, Texas City, Texas

REPUBLIC Oil Refining Company in the early part of the war was in a position similar to many plants throughout the country, that is, that due to rapid expansion, increased orders, construction work and shortage of trained personnel, the Safety Department had not enlarged as rapidly as it should. Consequently the accident ratio was greatly increased. In fact the increase had reached a point of about 156 accidents per month at the end of March, 1945, with a personnel of approximately 675-800.

From April, 1945 on, as a result of the program outlined herein, this accident ratio was decreased to a low of five accidents per month of a minor nature with an average of approximately seven per month. Through the use of a safety program the average number of lost time accidents was six per month during 1945, which dropped down to an average rate of one during the last six months of 1946 with a personnel of 400. This same latter rate is being maintained currently.

SAFETY SUGGESTIONS

No. 275

REPUBLIC OIL REFINING COMPANY

DESCRIPTION OF CONDITIONS: Clark Engine Room - When "heading up" barrels there is always the danger of strain to the individuals involved, especially if the footing is wet with water or oil. The usual strain effects the back muscles or abdominal walls.

HOW WOULD YOU REMEDY?: The attached crude diagram illustrates a device that possibly would eliminate much of the risk. The open mouthed hoop slides on and off barrels easily and prevents side slipping of the hook. The hook catches the barrel rim; the upward extension allows the shoulder to come under the lever; and from a "crouch" the barrel can be "ended up" by rising, the strain being absorbed by the leg muscles.

SIGNATURE: John Doe DEPARTMENT: Compressors DATE: 11-19-46

APPROVED SAFETY SUGGESTION COMMITTEE: John Jacob Doe DATE: 11-20-46

ACTION TAKEN BY CENTRAL COMMITTEE: Suggestion approved.

FINAL DISPOSITION: Installed.

How safety suggestions come from Republic workmen

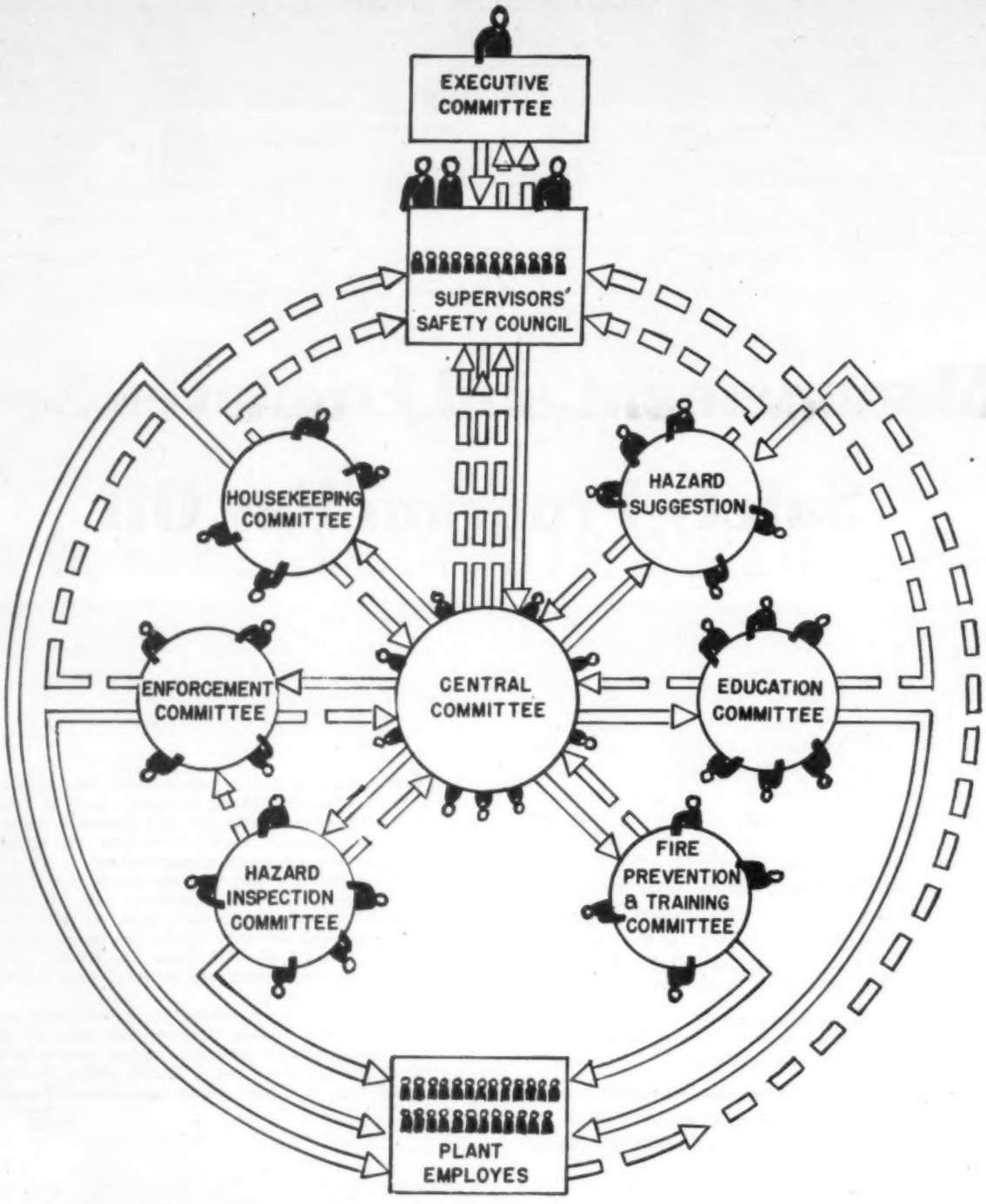
THE author's account of how accidents have been reduced at the Republic Oil Refining Company's plant at Texas City is "moral" enough for this story and requires no editor's note pointing to accrued benefits—both from the viewpoint of worker welfare and operating management.

But his article, setting forth the details of the setup and functioning of the safety department, does not include an important sidelight on a bigger payoff. We refer, of course, to the role which the safety organization took when, upon the occasion of the April, 1947, Texas City disaster, it stepped into a dangerous breach and virtually saved the Republic plant from destruction.

That's another story, perhaps, and an interesting one. It is mentioned here because it shows that once an efficient safety organization is perfected, it brings good dividends the year 'round and when and if disaster strikes, its value will be multiplied to a point almost beyond human computation.

During this accelerated safety program, the management has had full participation; hazardous situations were located and corrected before they resulted in accidents. Employes were made more safety conscious and plant protection was enlarged to the plant's size. The entire program centers around the diagram shown in Figure 1.

The Central Committee, meeting weekly, is composed of the chairman and the surrounding committees namely: Housekeeping, Enforcement, Hazard Inspection, Fire Prevention & Training, Education



Republic Oil Refining Company's Safety Set-Up. See listings under "By-Laws" (opposite page) for each committee's duties.

and Hazard Suggestion. These committees comprise members of all departments throughout the refinery and are governed by the constitution and by-laws as presented in connection with this article.

Monthly Review

The Supervisors' Safety Council, meeting monthly, reviews the entire safety program for that month. At every monthly meeting there is a definite program arranged for further instruction to all attending. The Executive Committee, composed of three members, is always available for consultation in problems that cannot be solved otherwise. Full cooperation has been obtained from all committees to make this program a success.

Each committee has its eyes open for its own as well as other committee's problems. Each committee is composed of supervisors throughout the plant with the idea that to sell the supervisor on safety is to sell the men as well—the supervisors being in the position to control both the acts of the workers and working conditions. Supervisors are delegated with specific authority for accident prevention, thus helping to avoid confusion in the prosecution of safety.

Further to aid in this program, a Bureau of Mines sponsored first aid training program was started. This training program included all plant personnel, including management, supervisors and clerical workers. The course is given in five days, three hours per day and is composed of twelve to fifteen persons in each class. These classes are schooled in standard Bureau of Mines first aid training courses. Certifi-

cates of satisfactory completion of courses are a proud possession eagerly sought by all.

Educational programs are based on instilling safety consciousness in the employe rather than trying to teach him to memorize a list of long, dry plant safety rules. Safety rules are posted in all parts of the plant and are there to keep all employes constantly safety minded. Safety is largely a matter of common sense and it is doubtful if the safest employe can recite a long list of safety rules. The existence of these rules has been impressed into every man's subconscious mind so that he will invariably recognize any unsafe practice or situation.

Interest is plant wide in the monthly supervisors' safety meetings and the minutes of these meetings, which include weekly meetings are posted on all bulletin boards. This gives the plant workers an opportunity to see their safety recommendations and what happens to each.

New recommendations are presented at all meetings. No recommendation is ever lost sight of. Each one not completed is carried over into the next meeting. Workers all know that once their recommendation has been submitted and approved it will get attention as soon as time and material permit. Three cash prizes are awarded monthly to the best safety suggestions submitted. There is also an inter-departmental safety contest with prizes awarded every three months.

Talks by Outsiders

Insurance company safety representatives are as interested in this program as are plant personnel

Constitution and By-Laws

CONSTITUTION

ART. 1. NAME, OBJECT AND GOVERNMENT.

Sec. 1. The name of this organization shall be the Supervisors' Safety Council of Republic Oil Refining Company.

Sec. 2. The object of this organization is to promote interest in Safety and the preservation of life and property.

Sec. 3. This organization shall be governed by this Constitution and By-Laws.

ART. 2. FUNCTIONS.

Sec. 1. To hold meetings once each month.

Sec. 2. To conduct plant inspections at regular intervals.

Sec. 3. To conduct investigations of accidents and near accidents.

Sec. 4. To sponsor the education of plant personnel for better accident prevention.

Sec. 5. To correct unsafe working conditions and habits as much as possible.

ART. 3. MEMBERSHIP AND OFFICERS.

Sec. 1. All of the plant supervisors are members of the Supervisors' Safety Council. The members of the council nominate and by popular vote elect the following officers to serve for a term of six months: Chairman, Vice-Chairman and Secretary.

ART. 4. DUTIES OF THE OFFICERS.

Sec. 1. Chairman: Plan meetings, preside at meetings, call for inspections and investigations, appoint the personnel of all committees, perform any other duties assigned him by the council.

Sec. 2. Vice Chairman: In the absence of either the Chairman or the Secretary the Vice Chairman shall assume their duties.

Sec. 3. Secretary: The Secretary shall keep all records, handle all correspondence take minutes of the meeting, and perform any other duties assigned him.

Sec. 4. The officers of the Council will serve as officers of the Central Committee.

ART. 5. MEETINGS.

Sec. 1. Meetings of the Supervisors' Safety Council will be held on the third Wednesday of each month at 1:00 p.m.

Sec. 2. Meetings of the Central Safety Committee shall be held on Tuesday of each week at 1:00 p.m.

Sec. 3. Special meetings may be called at the discretion of the Executive Committee the notice of such meetings to state the business for which the special meeting is called, and no other business shall be entertained or transacted at such meeting. Notices of special meetings shall be mailed one day in advance of date of meeting.

Sec. 4. One third of the persons entitled to vote shall constitute a quorum for the transaction of business at any meeting.

ART. 6. ORDER OF MEETINGS.

Sec. 1. The following order of meetings will be followed:
Roll call.
Reading of minutes of last meeting.
Unfinished business—
Reports of committees,
Other unfinished business.
New business—
Appointment of new committees,
New ideas for discussion.
Special feature—
Discussion,
Speaker,
Movies, Etc.
Adjournment.

ART. 7. AMENDMENT OF CONSTITUTION.

Sec. 1. A proposed amendment to this constitution in writing and signed by not less than three members may be adopted at any meeting, provided that it shall have been presented to the Secretary one month in advance of such meeting and published in the call for the meeting. If passed by a three-fourths vote of the members present it shall be considered finally adopted.

ART. 8. AMENDMENT TO THE BY-LAWS.

Sec. 1. A proposed amendment to the By-Laws may be presented at any meeting and if passed by a three-fourths vote of those present shall be finally adopted. Any such amendment, after adoption, shall be published by mail to all members of the organization.

ART. 9. ADOPTION OF THE CONSTITUTION.

Sec. 1. This constitution shall go into effect immediately upon its adoption.

BY-LAWS

ART. 1. ADMINISTRATION OF SAFETY PROGRAM.

Sec. 1. The administration of our Safety program shall be done by committees in the following fashion:
a) The following committees shall be appointed by the Chairman of the Council and for the Central Safety Committee:
1) Central Safety Committee.
2) Hazard Suggestion Committee.
3) Housekeeping Committee.
4) Hazard Inspection Committee.
6) Safety Education Committee.
6) Executive Committee.
7) Enforcement Committee.
8) Fire Prevention and Training Committee.

Sec. 2. The coordination of the activities of the other committees will be the responsibility of the Central Committee and they will determine policy and will energize the whole system. Specifically the duties for the Central Committee will include:
1) Listing the functions of the various sub-committees.
2) Appointing suitable members for the sub-committees.
3) Supervising the functions of all sub-committees.
4) Acting as coordinator between all sub-committees.
5) Handling all hazard suggestions according to the designated procedure and enforcing the satisfactory completion of all hazard correction projects.
6) Compiling a monthly report of all activities of the safety program.
7) Filing the minutes and reports of all sub-committees for future reference.
8) Approving all accident reports before submitting to plant manager.
9) Holding weekly meetings to transact business.
10) Referring certain issues to the Executive Committee for action. These include: a) Expenditure of money exceeding $50; b) Changing company policy; c) Establishing new company policy; d) Interpretation of company policy; e) Authorization of payment of wages for training periods; f) Interruption of production schedules; g) Discipline of employes for infraction of rules; h) Disagreements between department heads and the Safety Committee on hazard suggestions.
11) The Central Committee shall be responsible for all of its actions to the Executive Committee. The Central Committee will appoint the members of the sub-committees. The duties of these sub-committees will include the following:

A) **Hazard Suggestion Committee**—1) Providing a satisfactory mechanism for receiving hazard and housekeeping suggestions. 2) Meeting each week to consider the suggestions made during the past week. 3) Acknowledging all suggestions, good and bad. 4) Screening out all suggestions that do not apply to safety and referring them to the proper persons. 5) presenting bona fide hazard suggestions to the Central Committee with any recommendations that the members may have. 6) Reporting back to the suggestor the final disposition of all suggestions.

B) **Housekeeping Committee**—1) Conducting housekeeping inspections at regular intervals and issuing reports to the Central Committee of their findings. 2) Conferring with department heads concerning difficult housekeeping problems. 3) Making recommendations to the Central Committee for action on housekeeping improvement.

C) **Hazard Inspection Committee**—1) Conducting hazard inspections of specific items at regular intervals. 2) Conducting accident investigations. 3) Making periodic inspections of the results of safety suggestions. 4) Issuing a monthly report to the committee of first aid cases.

D) **Safety Education Committee**—1) Preparing and presenting safety training programs to the Council. 2) Supervising the program arrangements for departmental safety meetings. 3) Gathering information such as slides, movies, posters, bulletins, handbooks, etc., for safety meetings and bulletin boards. 4) Assisting the fire chief in conducting a fire training program. 5) Preparing exhibits for all bulletin boards. 6) Handling publicity for the Council.

E) **Enforcement Committee**—1) Defining the authority and discipline for enforcement of Safety Rules. 2) Enforcing compliance with properly sponsored safety suggestions. 3) Compiling a list of safety rules and the provision for their enforcement. 4) Making recommendations to the Executive Committee when disciplinary action is necessary. 5) Providing a uniform and publicized means of enforcing safety practices. 6) Confirming in writing to all supervisors matters of enforcement policy and practice.

F) **Fire Prevention and Training Committee**—1) Assisting fire chief in conducting a fire training program.

G) **Executive Committee**—1) Considering such issues as are brought before it by the Central Committee. 2) Determining company policy in respect to safety. 3) Reviewing the safety program.

Typical Minutes of Safety Group

Republic Oil Refining Company

CENTRAL SAFETY COMMITTEE MEETING

Meeting was called to order at 1:00 p. m. October 8, 1946. All members were present.

NOTE: All parties concerned with the hazards and suggestions listed below, please note and take any necessary action to complete this work as soon as possible before our next meeting.

OLD BUSINESS

There were five accidents reported for last month—two in the Light Oil Department and three in Maintenance. This has set a new all time low. A letter of congratulation was received by this committee from the Vice President of the company.

Walkways at 75 and 76 tanks have not been shelled but shell is on order and as soon as it is received, work will be done.

Drainage at the cat cracker is almost finished.

The laboratory truck drivers are complying with requests to drive more slowly around the plant.

Gas testing units are fixed. Two are available.

Schedule of working temperatures within vessels is being worked out. This was dropped because of cat cracker shutdown but will be further worked on this week.

NEW BUSINESS

Reports from the various committes were as follows:

Hazard Inspection Committee:

It was suggested that platforms be made on 1st and 8th floors of the cat cracker on the standpipe and riser in order to facilitate operation of valves. A work order should be written by the Operations Department.

A recommendation was made for better drainage near the ethyl pump house because of the fire that was started by a terminal locomotive. This should be acted on as soon as possible.

Safety Education Committee:

Safety instruction classes will be resumed next week. We will try to have the field director of the Bureau of Mines present to examine the class. Meeting for election of new officers will be held at 1:00 p. m. October 9 in the Conference.

Hazard Suggestion Committee:

No suggestions received.

Housekeeping Committee:

The building back of ethyl pump house should be relocated in order to keep fire fighting equipment in it. This is to be approved by the Light Oil Department.

Weeds in the North Farm should be cleaned up.

Firewalls in the North Farm have been cut into to repair leaks and have not been filled in. This should be done as soon as possible.

Lead cable reel on north road should be hauled to storage.

A jack at tank 43, which has been lying there for several weeks exposed to the weather, should be removed.

Out-of-service lines back of cooling tower should be salvaged. This also applies to tank 43 lines.

Enforcement Committee:

Cat walk should be built between compressor and treater pump house. This will be looked into.

Fire Protection & Training Committee:

We have only one asbestos suit for use in plant. It was recommended that we have at least two more and they are to be purchased.

The unsafe practice of draining liquids from the Midben gas manifold to open sewer should be corrected. There will be further discussion on this at the next meeting.

Some steam hose is missing and some misplaced. A survey will be made and more will be ordered.

Drainage east of the compressor room is to be improved.

Investigation will be made on the possibility of replacing existing rubber tires in foamite trailers with solid metal tires. Present tires have been unsatisfactory.

A map of the company property indicating different fire zones will be placed in the cat cracker for convenience of the person blowing fire whistle.

Meeting adjourned at 1:35 p. m.

and offer their fullest cooperation at all times with periodical attendance at the meetings, lending projection equipment and film, and giving posters for display. They are asked for regular suggestions which they may have after their inspection trips through the plant. Their broader experience has uncovered many hazards, some of which might have been missed by Republic's own personnel.

Programs also have included talks by safety directors from surrounding plants. Their problems were found to be the same as Republic's. The Bureau of Mines was very generous in offering the time and

DISPENSARY REPORT FOR March 1945

DEPARTMENT	EYE INJURIES: CHEMICAL	EYE INJURIES: FOREIGN BODIES	EYE INJURIES: DUST (WOOD)	EYE INJURIES: DUST METAL	EYE INJURIES: MISC.	FUNCTIONAL: NAIL	FUNCTIONAL: MISC.	BURNS: FIRE	BURNS: METAL (HOT LIME, ETC.)	BURNS: SCALD	BURNS: CHEMICAL	CONTUSIONS	LACERATIONS	ABRASIONS	FRACTURES	INFECTIONS	MISCELLANEOUS	SPRAINS	STRAINS	BURNED	MISC. MED.-SOC.	MINOR CASES	TOTAL FOR DEPARTMENTS
ADMINISTRATIVE																							
TECHNICAL SERVICE																							
ENGINEERING		1												1		1						9	3
OPERATIONS	1	3								2	1	1	1	3		1			1			6	14
LABORATORY		1					1	1		1							1				3	7	8
LIGHT OIL & CRUDE DISPATCHING	1									2	1		1	2									7
UTILITIES													1										1
MAINTENANCE	4	36		4	1		1	4	5	6	13	7	8	9			2		1			69	101
SAFETY DEPT.																							
PLANT PROTECTION																							
WAREHOUSE																			1				1
SOUTH FARMS												3		2									5
BARREL HOUSE										1		7				1			1			27	10
Bay Pipe & Steel		11										1		1									13
TOTAL CASES	6	53		4	1		2	5	5	11	16	19	11	18		3	3		4		3	118	156

1945, BEFORE

DISPENSARY REPORT FOR Month of February 1947

DEPARTMENT	EYE INJURIES: CHEMICAL	EYE INJURIES: FOREIGN BODIES	EYE INJURIES: DUST (WOOD)	EYE INJURIES: DUST METAL	EYE INJURIES: MISC.	FUNCTIONAL: NAIL	FUNCTIONAL: MISC.	BURNS: FIRE	BURNS: METAL (HOT LIME, ETC.)	BURNS: SCALD	BURNS: CHEMICAL	CONTUSIONS	LACERATIONS	ABRASIONS	FRACTURES	INFECTIONS	MISCELLANEOUS	SPRAINS	STRAINS	BURNED	MISC. MED.-SOC.	MINOR CASES	TOTAL FOR DEPARTMENTS
ADMINISTRATIVE																							
TECHNICAL SERVICE																							
ENGINEERING																							
OPERATIONS												1			1							4	2
LABORATORY																							
LIGHT OIL & CRUDE DISPATCHING																							
UTILITIES																							
MAINTENANCE		2												1								6	3
SAFETY DEPT.																							
PLANT PROTECTION																							
WAREHOUSE																							
SOUTH FARMS																							
BARREL HOUSE																							
TOTAL CASES		2										1		1	1							10	5

1947, AFTER

Documentary payoff of an efficient and systematic safety set-up

services of its representative. The Visual Education Board of the University of Texas provided safety films of all types upon request. These are only a few on the list of program material available.

As stated before, the procedure which is of vital importance in creating a workable safety program consists of two elements:

1) Management from top down must be interested in safety and must reflect such interest to the employes.
2) Educational safety programs must instill safety consciousness in the employe rather than giving a long list of dry safety rules to memorize. These lists should be posted where they are readily available for reference. In this manner the employe is constantly reminded that the company demands safety.

Safety is a matter of common sense and with safety rules and posters on department bulletin boards, every man will have impressed in his mind any unsafe practices or situations that might arise.

When a new employe is hired, after checking through the Industrial Relations Department and the refinery Medical Examiner, he is next sent to the head of the Safety Department. Here, specially prepared pamphlets of safety rules throughout the refinery are given to him for reading and a safety talk with diagrams and a review of past safety records are discussed in detail. He is shown the need for the use of safety apparel such as goggles, safety shoes, hard hats, gloves, etc. It is pointed out to him that there are accident hazards throughout the refinery and that by practicing safety and common sense these hazards are automatically removed. He is also invited to attend the next class offered on safety.

Impressing the New Employe

This procedure does two important things: It charges the new employe with the responsibility of being careful not to lower the refinery safety record through his own carelessness. Also it makes him realize that safety consciousness really works to the benefit of himself and his fellow workers.

The head of the Safety Department points out the hazards peculiar to the plant, safety rules of each department, location of first aid stations and mandatory rules regarding the use of various pieces of safety equipment. Emphasis is placed on the rule that all injuries, no matter how slight must receive first aid treatment to avoid further complications. Further to illustrate to the new employe, hazards that might be encountered, specific examples are illustrated such as the correct manner in lifting heavy objects, the correct use of all types of ladders, the correct manner in handling chipping guns, hose, carrying tools, and working around storage tanks and operating units, etc.

The new employe is then taken in to his foreman who again offers any safety suggestions that should be pointed out on this employe's first job. This practice has helped further to reduce the frequency of accidents in the refinery.

Our aim at Republic Oil Refining Company is increased recognition of the fact that by sticking to accepted working rules on any given job, requires safety-minded thinking on the part of every employe. This makes safety everybody's business and Republic Oil Refining Company a safe place to work.

Also presented herewith are the minutes of an average meeting of the Central Safety Committee and the Constitution and By-laws used in the refinery's safety program.

* * *

Effect of Solvent Composition and Primary Solvent Dilution on Dewaxing Filter Rates and Wax Oil Contents

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Refining Division, Magnolia Petroleum Company, Beaumont, Texas

THE effect of solvent composition and primary solvent dilution on dewaxing filter rates, wax oil content and ultimate yield of oil for a constant pour point are discussed here. Composition of a methyl ethyl ketone dewaxing solvent was varied between the limits of 0-100 percent methyl ethyl ketone and 100-0 percent toluene, and the primary solvent to oil dilution ratio varied through the range of 0:1 to 4:1. Experimental data show that the highest filtration rates are obtained at maximum permissible methyl ethyl ketone concentration. The upper limit for methyl ethyl ketone depends on the oil-solvent-temperature miscibility relationship. These data, also, disclose that the lowest slack wax oil contents are secured when the oil is chilled to the dewaxing temperature before adding solvent. For distillate stocks an optimum balance exists between primary solvent dilution and methyl ethyl ketone content of the solvent. The ultimate yield of constant pour point dewaxed oil is independent of solvent composition.

SOLVENT dewaxing of lubricating oils has been steadily increasing in importance during the past few years. At the present time the major processes employ solvents such as a mixture of benzene and methyl ethyl ketone, propane or chlorinated hydrocarbons. The experimental data presented in this paper refer to benzene-methyl ethyl ketone dewaxing; however, the same basic principles apply to all of these processes.

The most important requirement for efficient ketone dewaxing operations is production of a low oil content wax at high dewaxed oil output rates, normally associated with high filtration rates. Some of the major factors which control these variables include:

1) Size and type of wax crystals
2) Total dilution of oil charge
3) Rotation speed of the continuous rotary filters.

Size and type of wax crystals depend principally on a) solvent composition, b) primary solvent dilution, c) stock preparation methods, and d) chilling rates. Only the first two methods were studied in this work. Reeves[6] proved by mathematical analysis the existence of an optimum total dilution which gives the maximum dewaxed oil filtration rates. The relation between drum rotation speed and filter rate has also been derived by Reeves.[7]

Previous investigators have used ketones, other than methyl ethyl ketone, pure and blended with various compounds but none have reported the effect of wax anti-solvent concentrations in the solvent on filtration rates and wax oil content. Knowles[3] suggests a mixture of ketones and Texaco Development Corporation[8] uses methyl iso-butyl ketone blended or not blended with other solvents. Methyl n-butyl ketone was recommended by Pokorny and Stratford.[5] Mueller[4] described the use of a mixture of methyl n-butyl and methyl n-propyl ketones in a commercial dewaxing unit. Jenkins[1] states that straight chain paraffin waxes separate in an oil free condition when crystallized from the oil with which it is normally associated.

Solvent Composition

A raffinate having a Saybolt Universal viscosity of 73 seconds at 130° F. and prepared by solvent treating a Mid-Continent distillate was used in laboratory dewaxings. The percentage of methyl ethyl ketone in the solvent mix was varied from 0 to 100 percent and the dewaxing temperature adjusted so that a 30° F. pour point oil was produced from each run.

Filtration data obtained in these investigations are presented in Figure 1 and show that maximum rates are secured with a solvent composed of 100 percent methyl ethyl ketone. In present commercial operations utilizing single dilution of a solvent mixture containing 40 percent of this anti-solvent is employed. The use of pure methyl ethyl ketone will double the output of the dewaxed oil at constant filter rotation speed and vacuum.

The ultimate yield of 30° F. pour point oil obtained in the laboratory experiments was not affected by the changes in solvent composition. This contradicts somewhat the previously reported data[2]; however, it is pos-

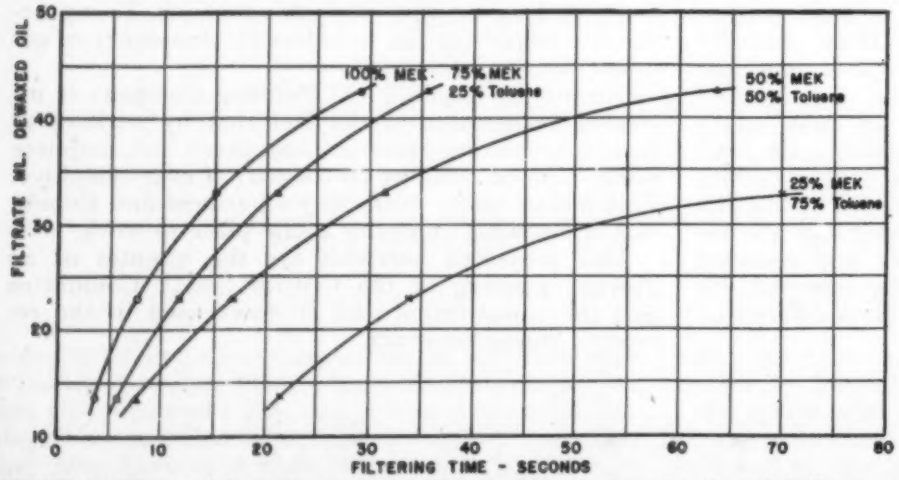

FIGURE 1—Effect of Solvent Composition on Filtering Rates in Dewaxing Neutral Raffinate to 30° F. Pour Point. (Solvent-to-oil ratio—4:1.)

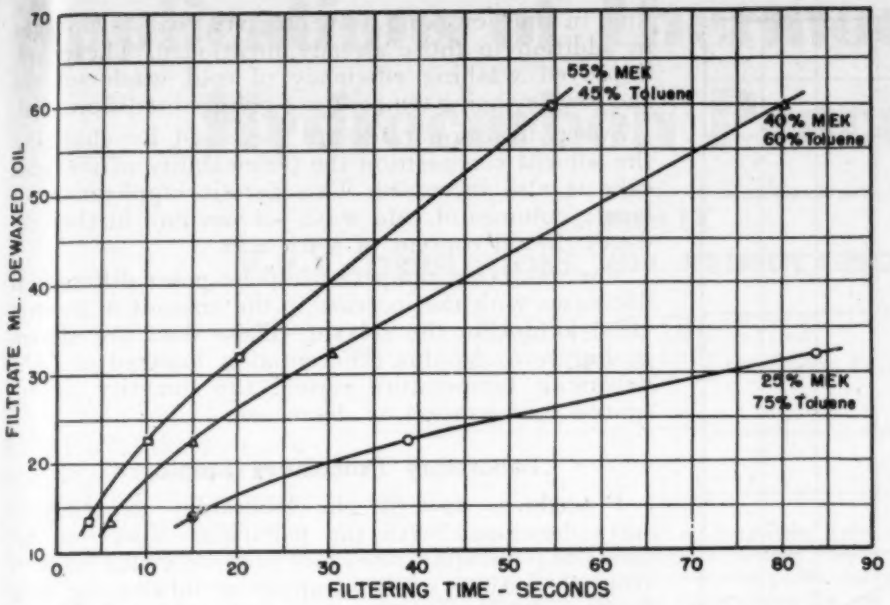

FIGURE 2—Effect of Solvent Composition on Filtering Rates in Dewaxing Residual Raffinate to 20° F. Pour Point. (Solvent-to-oil ratio—4:1.)

sible that the discrepancies might be explained by the inherent differences in the nature of the materials tested or by phase separation which might have occurred in these former investigations. The latter phenomenon was observed in our studies when extremely low cooling bath temperatures were employed.

The oil content of the unwashed slack wax remained constant in all experimental runs.

In subsequent experiments a raffinate having a Saybolt Universal viscosity of 95 seconds at 210° F. and prepared by solvent treating a Mid-Continent residuum was employed. The percentage of methyl ethyl ketone in the solvent mix was again varied from 0 to 100 percent and the dewaxing temperature adjusted so that a 20° F. pour point oil was produced from each run.

Filtration data obtained in the second series of investigations are presented in Figure 2 and show that maximum rates are obtained with a solvent composed of 55 percent methyl ethyl ketone. At concentrations of anti-solvent above 55 percent the oil phase separation was very pronounced resulting in abnormal filter rates and low yields.

Oil solvent miscibility data for both the raffinates studied are given in Figure 3.

Double dilution reduces filtration rates although this reduction may not be noticeable in plant operations because of the presence of many other variables, such as, rate of filter rotation. The main advantage of this operating method consists, therefore, in the reduction of oil content of slack wax.

The experiments dealing with the effect of solvent composition on filtration rates indicated that both improved oil throughput and a reduction in the wax oil content could be achieved by employing pure methyl ethyl ketone for primary dilution and pure toluene for secondary dilution. This work showed that filtration rates were better than those secured with double dilution employing mixed solvents and became equal to those observed with single dilution procedure where the charge stock is mixed with the whole quantity of solvent. Oil content of the slack wax was the same irrespective whether methyl ethyl ketone was mixed with toluene or applied separately in the double dilution experiments. The effect of varying the relative proportions of solvents used for primary and secondary dilutions on the oil content of slack wax is shown in Figure 4.

The data in Figure 4 demonstrates that the lowest oil contents of slack wax are obtained at the lowest primary solvent dilutions. This indicates that best

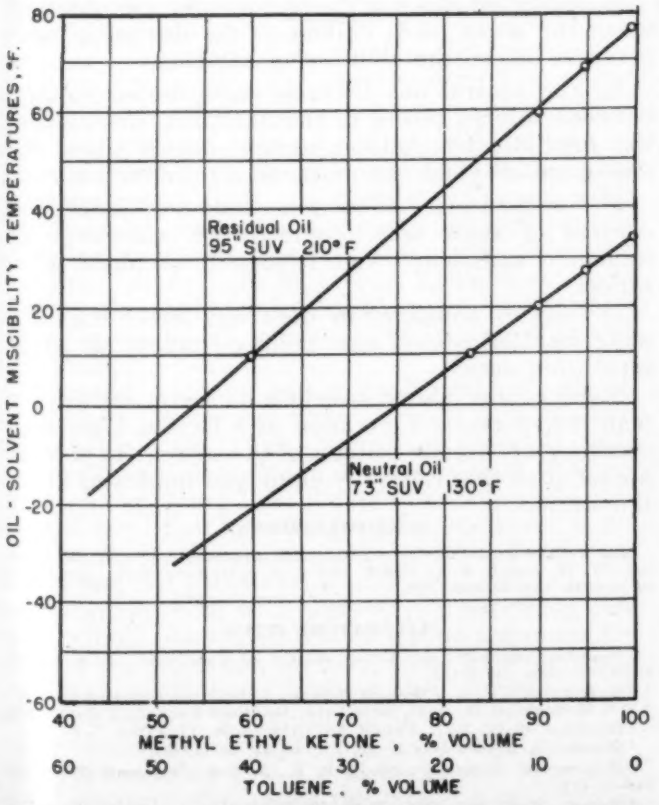

FIGURE 3—Dewaxed Oil-Solvent Miscibility Temperatures for the Stock Studied.

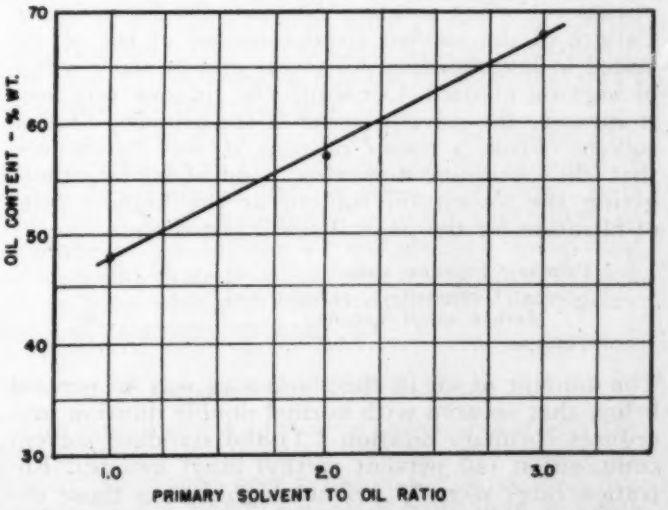

FIGURE 4—Effect of Primary Dilution on Slack Wax Oil Content. (Total solvent-to-oil ratio—4:1.)

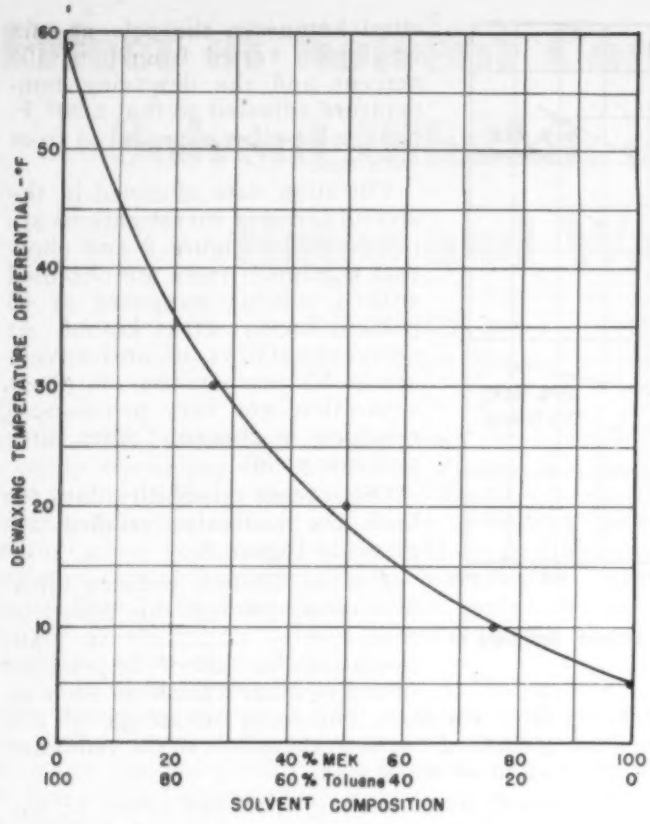

FIGURE 5—Effect of Solvent Composition on Dewaxing Temperature Pour Point Differential. (4:1 solvent-to-oil ratio.)

results in this respect are obtained by first chilling the undiluted oil to the dewaxing temperature and then leaching it with the cold solvent. These conclusions are in agreement with experimental observations and the data of Jenkins.[1]

Optimum Dewaxing Conditions

It has been previously shown that the highest rates of filtration are secured with pure methyl ethyl ketone and that the lowest slack wax oil contents are obtained at the lowest primary solvent dilutions. The laboratory work was, therefore, extended to combine these variables and determine the optimum dewaxing conditions for the distillate stock.

In these experiments it was found that the low solvent power of methyl ethyl ketone does not permit its use when primary dilutions are 1.1 or lower. Failure of the solvent to dissolve all of the oil resulted in low dewaxed oil yields and in slack waxes of high oil content. Consequently, toluene was used to increase the solvent power of the primary dilution solvent. From a series of runs it was determined that the optimum dewaxing conditions, i.e., those giving the lowest oil content at the highest rates of filtration for the neutral stock tested were:

Primary Dilution ratio	0.5:1
Solvent Composition, percent Vol.	
Methyl ethyl ketone	85
Toluene	15

The amount of oil in the slack wax was 35 percent below that secured with normal double dilution procedures (primary dilution 1:1) and standard solvent composition (40 percent methyl ethyl ketone). Filtration rates were 75 percent higher than those experienced under conventional operation.

The use of large percentages of methyl ethyl ketone in the dewaxing solvent gives two advantages in addition to those already mentioned. These are, improved washing efficiency of cold wash solvent and low dewaxing temperature-pour point differential.

When filtration rates are increased by changing the solvent composition the permeability of the wax cake is also increased. This permits application of larger volumes of cold wash solvent and further reduces the oil content of slack wax.

The dewaxing temperature-pour point differential decreases with the increase in the amount of methyl ethyl ketone in the solvent. These data are shown in Figure 5. As this differential is lowered and the dewaxing temperature raised, the quantity of required refrigeration is decreased.

Laboratory Procedures Employed

Procedures used in the laboratory experiments were developed with the particular object of determining filtration rates and product yields secured from dewaxing small samples of lubricating oils. Waxy oil-solvent mixtures were chilled with constant mechanical agitation in a cooling bath which was never more than 20° F. below the anticipated dewaxing temperatures. Filtrations were made in a Buchner funnel. Ultimate yields and slack wax oil contents were determined by the dilution ratio method.

Conclusions

The results of these experiments may be summarized as follows:

1) Maximum rates of filtration for both distillate and residual oils are obtained at the highest permissible methyl ethyl ketone content in the solvent mixture. The maximum methyl ethyl ketone content is limited by oil phase separation temperatures for the particular stock employed.

2) Minimum slack wax oil contents are obtained when the waxy oil is chilled to the dewaxing temperature before the addition of solvent.

3) For neutral oils there is an optimum balance between solvent power of the dewaxing solvent and the methyl ethyl ketone content which gives the maximum oil yield and dewaxed oil production rate.

4) Composition of solvent does not affect oil content of slack wax provided the percentage of toluene is sufficiently high to prevent oil phase separation.

5) Solvent composition does not affect the ultimate yield of a fixed pour point oil unless oil phase separation occurs.

Some of the above conclusions were verified by plant experiments. Operation of a Ketone Unit with methyl ethyl ketone content of the solvent 15 percent higher than that normally employed improved filtration rates.

ACKNOWLEDGMENT

The writers would like to express their appreciation to J. W. Newton, W. W. Leach, P. L. Smith and V. A. Kalichevsky for permission to publish this manuscript.

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Applications of Thermodynamics to Hydrocarbon Processing

Part IX

P-V-T CORRELATIONS FOR HYDROCARBON SYSTEMS

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P-V-T correlations are used in calculating hydrocarbon vapor densities for sizing processing equipment. They are also used in deriving thermodynamic properties, such as fugacities, entropies, enthalpies, etc., for hydrocarbons. For the first application, it is not necessary to have as precise a P-V-T correlation as is required in deriving thermodynamic properties because of the nature of the two applications. Further, it is important that the P-V-T correlation used in the latter application be internally consistent so that irregularities will not be exaggerated in the derivatives which might lead to incorrect thermodynamic properties.

As pointed out in the last installment, P-V-T correlations may be graphical or analytical equations. Graphical P-V-T correlations have the advantages of presenting a visual picture of a vapor's volumetric behavior and also being more rapid to develop. Analytical equations of state have the advantages of mathematical consistency and requiring fewer experimental data in their development.

Both graphical and analytical methods may be generalized by employing reduced conditions computed from the critical conditions for single components and from the pseudo critical conditions for mixtures. Equations of state may also be applied to mixtures by combining the constants of the constituents to get constants for the multicomponent system, which procedure is related to the pseudo-critical.

DURING the past two decades considerable progress has been made by physical chemists and process engineers in obtaining experimental P-V-T data for hydrocarbons and in correlating and applying these data. Although progress has been made, the job is not yet finished. In fact much of the past calculation work will have to be done over because of a need for greater precision and because more experimental data are now available and additional data will gradually become available.

High-pressure refining processes have been responsible for most of the work done on hydrocarbons. It has been necessary to find the effect of deviations from the ideal gas laws on vapor-liquid equilibrium and on the enthalpy. When design tools were needed, they were developed from the best P-V-T and other data available, making assumptions, generalizations, estimates and even guesses where data were not available. In the light of present knowledge, many of these thermodynamic developments of the early 1930's for the hydrocarbons can be improved as well as extended.

Increased accuracy and extended range both involve more calculation work as well as additional experimental data. It was pointed out in Part VIII that the analytical equation of state method of correlating and applying P-V-T data is usually more precise and consistant than the graphical method. On the other hand, the graphical method with reduced conditions and the pseudo-critical saves a great deal of time when working with a group of compounds, like hydrocarbons. Increased accuracy is an argument for an analytical equation method while extending the work to include more hydrocarbon systems is an argument for the graphical method.

The ultimate procedure for correlating and applying hydrocarbon P-V-T data might well be an analytical equation of state but this would require a considerable investment of calculating time. In view of the number and complexity of hydrocarbon systems, it appears that the most practical procedure for deriving thermodynamic properties for petroleum is to use a graphical residual volume method and spot-check by rigorous equation of state calculations and also by observed values of the enthalpy, etc. In this suggested procedure the graphical residual technique would be applied with reduced conditions using critical and pseudo-critical conditions for single and multicomponent systems, respectively. In spot-checking mixtures with the equation of state, the empirical constants for the mixture would be found by combining the constants for the individual components. This would check the use of the pseudo-critical and confirm the method of evaluating the pseudo-critical point for mixtures.

As pointed out in the previous chapter, three types of graphical P-V-T correlations have been used for the hydrocarbons. These are: a) the reduced isochor (P_R vs T_R for lines of constant V_R) plot; b) the gas compressibility (PV/RT vs P_R for lines of constant T_R) plot; and c) the reduced volume residual (α_R vs P_R for lines of constant T_R) plot.

So much attention has been given to the generalized correlations of P-V-T data, that the importance of new experimental data is often overlooked. It is true that a given amount of experimental data can be made to go further by imaginative correlating methods but there is a limit to how much of the job can be done with pencil and paper only. Laboratory data are necessary as well.

Experimental P-V-T Data

The experimental apparatus and procedure for the determination of pressure — volume — temperature data for vapors has been reported in the technical literature. Sidney Young's work of more than 50 years ago in England established an apparatus design and

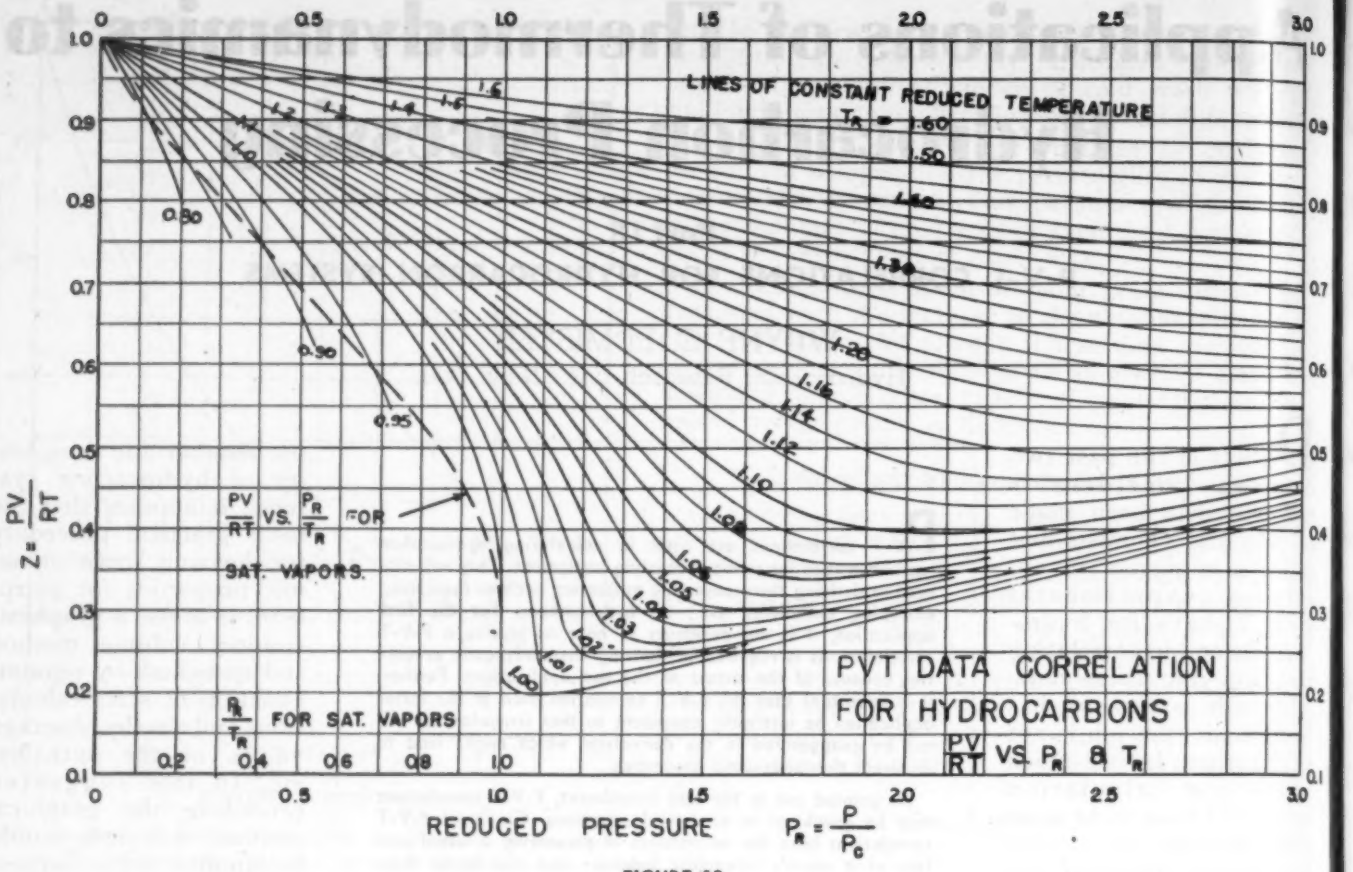

FIGURE 19

an experimental procedure for hydrocarbons that is still used, with slight modifications, today.

A complete bibliography of available experimental data is much too long to include here. Besides Sidney Young, other well known investigators in this field are Beattie, Keyes, et. al. of Massachusetts Institute of Technology, Sage and Lacey[20] of California Institute of Technology, Kay[1,12,13], and others [2,5,14,25]. With these references it would be a simple matter for any one interested to run down all the literature on the subject. It is appropriate to comment briefly on some of this work.

Bahlke and Kay[1] obtained P-V-T data on two light petroleum fractions. Later Kay[12,13] obtained P-V-T data on eleven typical hydrocarbon mixtures and on n-butane. With these mixture P-V-T data, Kay developed the pseudo-critical concept.

Sage and Lacey[20] have measured the P-V-T data for many hydrocarbons and some mixtures as a part of their work on "Phase Equilibria in Hydrocarbon Systems," which was Research Project 37 of the American Petroleum Institute. Most of the Sage and Lacey P-V-T measurements were at or near the two-phase border curve because of their primary interest in phase equilibria.

Experimental determination of P-V-T data involves measuring and/or controlling four variables, two intensive and two extensive. Pressure and temperature are the intensive variables, while mass and volume are the extensive variables.

Either of two procedures may be followed. Temperature may be held constant and pressure and volume measurements made. Or, alternately, volume may be held constant and pressure and temperature measurements made. The first procedure was used by Sidney Young, Sage and Lacey and by Kay. The latter procedure was used by Beattie et. al. Volume is an extensive variable and more difficult to measure accurately, which is an argument for keeping it constant. On the other hand, apparatus to keep volume constant is more complex than apparatus to keep temperature constant. With an "explicit-in-pressure" equation of state, the constant volume P-V-T measurements are most convenient.

The equipment required for P-V-T measurements consists of the following apparatus: a) sample purification, testing and filling facilities; b) calibrated variable-volume tube, cell or chamber; c) sample stirrer; d) compressor for supplying pressure to the sample; e) balance or gauge for measuring pressure; f) constant temperature bath or other device to maintain isothermal conditions in the sample and its container; and g) potentiometer or bridge for measuring temperature.

The purity of the sample is very important because dissolved air, water or other foreign matter can invalidate the results of much work. Also an accurate weight of the sample charged is necessary for the data to mean anything. When the sample is a mixture, the preparation is more complex. For a mixture it is usually best to prepare the sample by mixing known amounts of previously purified individual components, rather than start with a commercial mixture and risk errors in analyzing.

Temperature control and temperature measurement may be separate or integrated. With good controls and adequate heating elements it is possible to change temperature readily. Kay used organic liquids of different boiling points in his apparatus so changing temperature meant changing the temperature control fluid.

Kay's apparatus was simple. It had to be for one man operation. And yet many good data were obtained. Only a great experimentalist could have been so productive while working under the handicaps he had. For example, a pressure measuring balance does not have to be calibrated as frequently as the spring gage Kay used. Also the small high pressure capillary tubes used by Kay had to be changed frequently because of their limited volume range. Other laboratories making experimental P-V-T measurements were better equipped and manned. With better equipment and at least two men, data can be obtained faster and better.

This discussion of the experimental determination of P-V-T data is included to give the readers an appreciation of the laboratory work back of the thermodynamic correlations and derivations being discussed in these articles. Also it is hoped that a few of the readers will be inspired to undertake experimental work along these lines. Progress on this subject will be made by both laboratory and desk work.

Types of Graphical P-V-T Correlations

The reduced isochor plot was illustrated by Figure 17 in Part VIII. The advantage of this plot is that the isochors (or isometrics, as they are sometimes referred to) are straight lines. Disadvantages are that the critical volume is a correlating constant and that the slope and intercept of the isochors on a P_R vs T_R plot are not unique functions of reduced volume and independent of the component. This plot would be very useful if the same reduced volume points for different hydrocarbons fell on a single line. This type of plot was used by Brown et al,[2] by Lewis,[16] by Lewis and Luke,[17] and by Gilliland.[10]

The compressibility (PV/RT) plot, which is illustrated by Figure 19, is the most convenient graphical P-V-T correlation because the only component characterizing variables required are the critical temperature and critical pressure and because the PV/RT ratio enters into the design calculations as a straight multiplying factor. This type of P-V-T correlation has been applied to hydrocarbons by Brown et al,[2] Cope, Lewis and Weber,[3] Lewis,[16] Kay[12,13] Sage and Lacey,[20] Watson[26,27] and by many others [5,14,25, etc.] In addition to the thermodynamic development work, the PV/RT correlation has been used extensively in process engineering calculations.

The reduced volume residual plot was applied to hydrocarbons by the writer,[7] a few years after the publication of the isochor and compressibility plots described above. Residual volume quantities had been previously described by Lewis and Randall,[18] and applied to nitrogen, carbon monoxide and hydrogen by Deming and Shupe.[4] Graphical calculations made with volume residuals give greater accuracy, with the same amount of work, than can be obtained by making the same type of calculation with actual volumes, or compressibilities. The use of volume residuals has a feature that is an advantage and at the same time is a weakness; namely, the use of the critical volume residual, α_c. This gives an additional characterizing constant, making three (T_c, P_c and α_c). The latter constant is found from the critical volume which is not very accurately known so this is a weakness. However, the critical volume residual may be adjusted if need be to make derived data agree better with observed.

The graphical P-V-T correlations described above were prepared from experimental data on single component hydrocarbon systems and then applied to mixtures by means of the pseudo-critical concept of Kay.[12] As will be shown later, this is somewhat equivalent to the equation of state method of handling mixtures wherein the empirical constants of the individual components are combined.

This connection plus the fact that equation of state constants can be obtained from the critical constants of the fluid in question make an interesting three-way relationship.

Reduced Isometrics

As shown in the previous chapter, by Figure 17, lines of constant reduced volume are straight on reduced pressure vs. reduced temperature scales but lines for the same reduced volume for different hydrocarbons do not coincide. This type of correlation has many interesting theoretical aspects. Even though it is not very useful in routine process engineering calculations and it will not be used in deriving thermodynamic properties for hydrocarbons, it will be discussed to contribute to the understanding of P-V-T correlations. The isometric plot is, in a sense, a link between analytical equation of state and the graphical P-V-T correlations.

One objective in discussing the isometric P-V-T plot is to demonstrate the close relationship between different methods of correlating P-V-T. Both graphical and analytical methods are compatible. This discussion also outlines the ways P-V-T correlations are obtained for mixtures, i.e. first obtaining P-V-T correlations (graphical or analytical) for pure substances, and then applying to mixtures by combining constants or using pseudo-criticals.

It has been found that lines of constant volume on a pressure versus temperature plot are essentially straight lines and that the slope and intercepts of these lines are functions of volume. Expressed mathematically

$$P = MT - B \qquad (171)$$

where: M = slope of constant the volume lines on pressure vs. temperature scales.
$-B$ = the pressure intercept at $T = 0$.

M and $-B$ are functions of volume for each component. Equation 171 was suggested by Lewis and Luke[17] and later used by Gilliland.[10] The reduced generalized form of this equation was proposed by Brown, Souders and Smith[2] about the same time Lewis and Luke published their work. The reduced form is

$$P_R = M' T_R - B' \qquad (172)$$

where: M' = slope of the constant reduced volume lines on reduced pressure vs. reduced temperature scales.
$-B'$ = the reduced pressure intercept at $T_R = 0$.

M' and $-B'$ are functions of the reduced volume, but not unique functions as they vary with the component, as can be seen by Figure 17. Both equations 171 and 172 are explicit in pressure, which is not convenient. The reduced form of the equation will be discussed later after considering equation 171.

Referring to the Van der Waals equation of state in Part VIII, it can be seen that the slope and in-

tercept of equation 171 are equivalent to the $R/(V-b)$ and the a/V^2 terms in equation 164 (Part VIII), or

$$M = \frac{R}{V-b}$$

$$B = \frac{a}{V^2}$$

where: a and b are the Van der Waals constants. The constant b is the correction to the total volume for the actual volume occupied by the molecule, the difference $(V-b)$ being the volume available for molecular motion, which makes M inversely proportional to the molecular volume. The term a/V^2 is sometimes called the "internal," the "cohesive" or the "intrinsic" pressure.

The above discussion of the isometric form of the P-V-T plot gives the slopes and intercepts in terms of the Van der Waals constants. They could also be expressed in terms of the constants of other equations of state. Dodge[7] put the Keyes[15] equation of state, which has four empirical constants, into isometric form.

Brown et. al.[2] used equation 172 for single component hydrocarbon systems, expressing M' and B' as functions of the critical and the reduced volume. In this correlation critical volume is the component characterizing variable that compensates for the spread between the lines of the constant reduced volume for different pure hydrocarbons. These relations are

$$M' = x\, V_c^{w}$$

$$-B' = y\, V_c^{0.455}$$

where y, y, and w are functions of V_c. The x, y, and w functions of V_c are given graphically by Brown, Souders and Smith.[2]

Lewis and Luke[17] used the reduced isometric P-V-T correlation in their work on phase equilibria. Also Lewis[16] used such a plot in deriving the effect of volume on the internal energy, E. This was done by making a graphical integration of a function of V_r and including in the results component characterizing constants. This work will be discussed later.

It is of interest to note that the Van der Waals equation can be put into reduced form (See page 177 of Dodge.[7]) Rearranging the equation given in this reference gives

$$P_r = \frac{8\,T_r}{(3\,V_r - 1)} - \frac{3}{V_r^2} \qquad (173)$$

Equation 173 is the same as equation 172 where

$$M' = \frac{8}{3V_r - 1}$$

$$B' = \frac{3}{V_r^2}$$

These relations show the slopes and intercepts of the reduced isometric plot as functions of reduced volume only, for gases that follow the Van der Waals equation. Hydrocarbons do not follow Van der Waals equation, so these relations are of academic interest only.

The use of isometrics with graphical residuals to allow for the deviation from a straight line is one method of computing thermodynamic properties. York's[26] work along these lines will be discussed later.

Gas Mixtures

There are two gas mixture laws of interest in connection with P-V-T correlations. One is Dalton's law of *additive pressures* and the other is Amagat's law of *additive volumes*. Methods of combining equation-of-state constants for gas mixtures are developed from different assumptions about adding pressures and volumes.

Gilliland[10] used the isometric equation 171 in calculating pressures for gas mixtures at different temperatures and volumes. Various methods of combining the constants in equation 171 were tried. Each method was based on fundamental assumptions about adding pressures and volumes. The most satisfactory method found for calculating pressures of gas mixtures was based on: a) arithmetic summation of isometric slopes of the individual components to obtain slope for mixture, i.e. $M_{mix.} = \Sigma x_i M_i$; and b) the isometric intercept for mixtures from the intercepts of the individual components by the following relation:

$$B_{mix.} = [\Sigma\, x_i\, B_i^{1/2}]^2. \qquad (174)$$

Writing equation 171 for a mixture

$$P_{mix.} = M_{mix.}\, T - B_{mix.} \qquad (175)$$

From basis (a) above and equation 171

$$M_{mix.}\, T = \Sigma x_i (P_i + B_i) \qquad (176)$$

Combining these relations gives

$$P_{mix.} = \Sigma x_i P_i + \Sigma x_i B_i - [\Sigma x_i B_i^{1/2}]^2 \qquad (177)$$

where:

x_i = mol fraction of component "i" in gas mixture.
P_i = pressure of component "i" corresponding to the total volume of the mixture at the system temperature.
B_i = the negative pressure intercept of equation 171 at $T = 0$ for component "i."

Equation 177 is a more general form of Gilliland's equation 13, which gave the best results of the different methods tried in computing the pressure for binary mixtures. Equation 177 should be equally applicable for multicomponent systems as for binary mixtures.

The application of equation 177 would require values of P and B for each component in the system. P could be computed for the given temperature from equation 171 and the values of M and B corresponding to the volume in question. Knowing P and B for each component, it is a simple matter to substitute into equation 177 and find the pressure of the mixture.

For these calculations it is necessary to have correlations for predicting M and B. Gilliland[10] presented a plot of B/P_c (the value of P_r at $T_r = 0$) vs. V/V_c (reduced volume) for several fluids, but did not correlate the slopes.

Following are a few points from Gilliland's[10] plot to show how the intercepts on a reduced isometric plot vary for the different gases:

	Values of B/P_c For			
V/V_c	H_2	CH_4	C_2H_4	Heavier Hydrocarbon
2.0	0.8	1.4	1.6	2.0
4.0	0.2	0.35	0.4	0.58
6.0	0.09	0.175	0.19	0.29

These lines are essentially straight on log-log paper. Gilliland[10] used this plot to estimate B but did not employ reduced conditions otherwise. A cor-

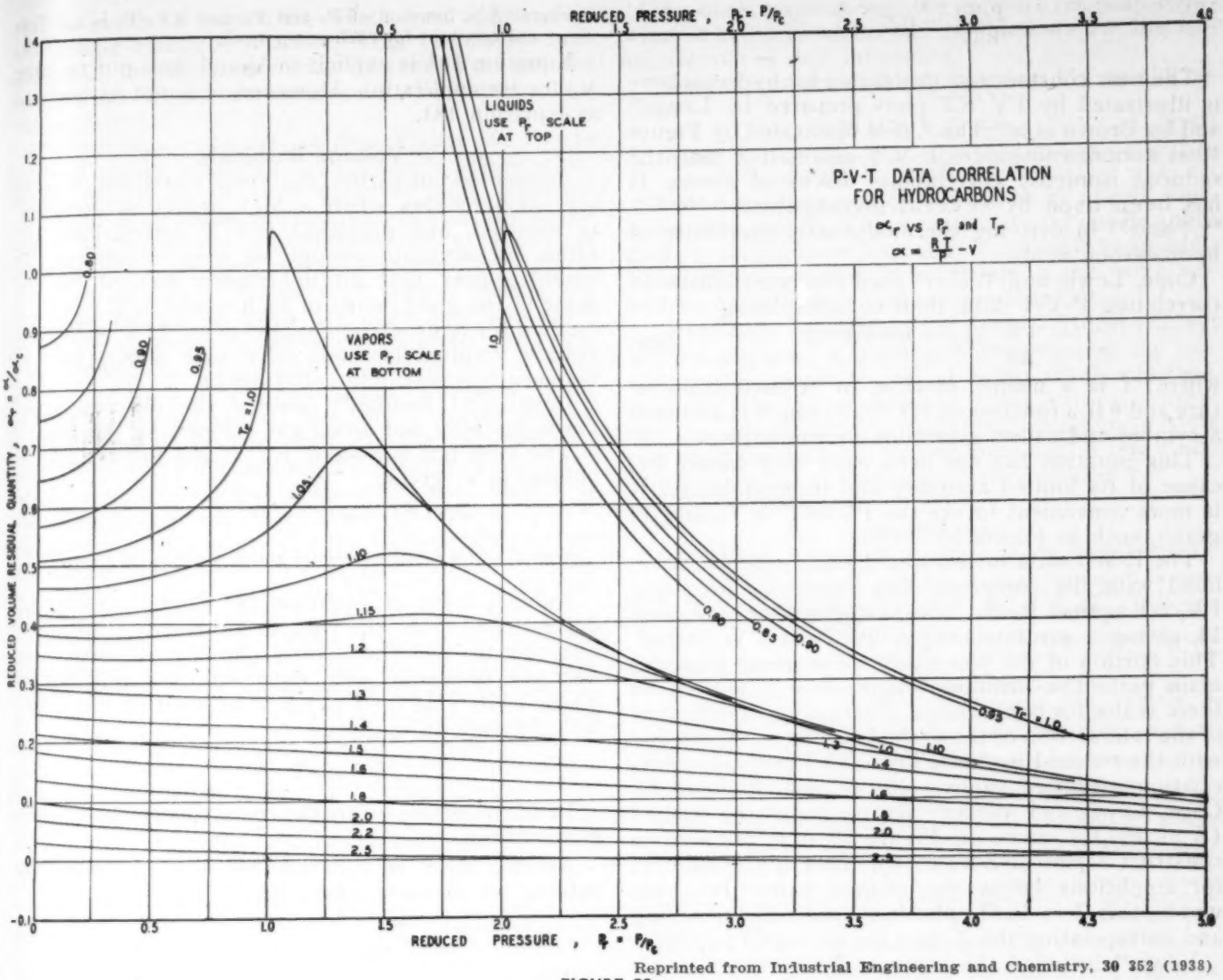

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FIGURE 20

relation was not presented for the slope, M.

While the use of equations 171 and 177 together with correlations for M and B will give pressures for mixtures of gases, this method is not convenient for making thermodynamic derivations. The reduced form of the isometric equation is more satisfactory for this purpose.

Compressibility Factor

The ratio of actual volume, V, to the perfect gas law volume, RT/P, is the compressibility factor, Z, where

$$Z = \frac{PV}{RT} \qquad (178)$$

Figure 19 is a plot of the compressibility factor, Z, vs. reduced pressure for lines of constant reduced temperature. This plot was made for hydrocarbons, using the data for ethylene and pentane and drawing the best average line possible for each reduced isotherm, thus averaging and smoothing the data.

This compressibility factor is a very useful thermodynamic function. It is of interest to consider the PV/RT ratio from various points of view so as to be thoroughly familiar with all aspects of it.

In the previous chapter, equations for the computation of the constants for the Van der Waals equation were presented but not derived. It was explained that these equations for a and b (equations 165 and 166) were obtained by differentiating the Van der Waals equation of state to obtain $\left(\frac{\partial P}{\partial V}\right)_T$ and $\left(\frac{\partial^2 P}{\partial V^2}\right)_T$, which must be zero at the critical. From these conditions the following are found, as is shown by Dodge

$$V_c = 3b$$

$$T_c = \frac{8a}{27\,Rb}$$

$$P_c = \frac{a}{27\,b^2}$$

Combining the latter two and solving for a and b gives equation 165 and 166.

Combining all three gives the following compressibility factor at the critical point for all gases that follow Van der Waals equation of state:

$$\frac{P_c V_c}{RT_c} = \frac{3}{8} = 0.375$$

Critical point compressibilities have been computed for many gases and tabulated in handbooks and textbooks. From these it can be seen that the P_cV_c/RT_c ratio is not a constant for all gases, but varies between 0.20 and 0.33 for the common gases.

The critical point compressibility factor for hydrocarbons is about

$$\frac{P_c V_c}{RT_c} = 0.27$$

The near constancy of this factor for hydrocarbons is illustrated by PV/RT plots prepared by Lewis[16] and by Brown et al.[2] The Z plot illustrated by Figure 19 is a more convenient P-V-T correlation than the reduced isometric correlations discussed above. It has been used by several investigators[2, 8, 12, 13, 16, 21, 26] and [27] in deriving thermodynamic properties of hydrocarbon fluids.

Cope, Lewis and Weber[3] used compressibilities in correlating P-V-T data, their equation being

$$\frac{PV}{RT} = e^{-RTf/P_c V + \phi} \qquad (179)$$

where: f is a unique function of reduced temperature and ϕ is a function of $RT/P_c V$, which is assigned a symbol and called a variable by the authors.

This equation has not been used very widely because of its limited accuracy and its complexity. It is more convenient to use the PV/RT vs P_r and T_r graph, such as Figure 19.

The P-V-T data for saturated vapors can be correlated with the compressibility factor by plotting PV/RT against P_r/T_r. This has been done on Figure 19, giving a saturated vapor line, which is dashed. This portion of the plot could be separate from the main part. The saturated vapors line is plotted on these scales for convenience. There is no significance in the intersection of the dashed saturated vapors line with the reduced isotherm lines. This method of correlating saturated vapor volumes was proposed by Cope, Lewis and Weber.[3] By means of the dashed (Z vs P_r/T_r) curve on Figure 19 it is possible to construct a plot of Z vs P_r for lines of constant T_r for conditions below the critical point. In other words, this Z vs P_r/T_r plot is a means of smoothing and extrapolating the Z data for saturated vapors.

Lewis[16] included the compressibility chart in his paper on high-pressure calculations, and Brown, Souders and Smith[2] used the PV/RT plot to obtain fugacities and phase equilibrium constants. Watson and Smith[27] used the compressibility plot to find the isothermal pressure correction to the enthalpy.

This type of plot is very convenient and may be used where its accuracy is satisfactory. The methods of using the PV/RT plot in deriving thermodynamic properties will be discussed in a later installment. For these thermodynamic derivations, a generalized reduced equation of state, using the compressibility factor, may be written as follows:

$$Z = \frac{PV}{RT} = \frac{(P_c V_c)}{(R T_c)} \frac{P_r V_r}{T_r} \qquad (180)$$

When the critical point compressibility factor is the constant 0.27 as shown above, and the compressibility factor, Z, is a function of P_r and T_r, as shown on Figure 19, equation 180 becomes

$$V_r = \frac{Z}{0.27} \frac{T_r}{P_r} \qquad (181)$$

Equation 181 is explicit in V_r and is in a simple and convenient form. The use of equation 181 requires values of P_c, T_c and V_c to compute V from P and T and a Z plot. Another generalized reduced equation of state using the compressibility factor is obtained by eliminating the V_c term. Replacing V_r in equation 180 with its equivalent V/V_c, gives the following:

$$V = Z \frac{(R T_c)}{(P_c)} \frac{T_r}{P_r} \qquad (182)$$

where: Z is function of P_r and T_r, and RT_c/P_c is a different constant for each component.

Equation 182 is explicit in V and does not require V_c for its application. However, it is not as general as equation 181.

Volume Residuals

As pointed out earlier, analytical equations of state are very complex where a high degree of accuracy is required, and graphical P-V-T correlations are often not accurate enough or even consistent. It would appear that an in-between method having some of the good points of each would be the logical method for hydrocarbon applications. In a sense, the volume residual methods offer such a compromise between precision and convenience.

Lewis and Randall[18] denoted the difference between the *ideal* and *actual* gas volumes by the symbol α. The ideal gas volume is RT/P and the actual gas volume is V, giving

$$V = \frac{RT}{P} - \alpha \qquad (183)$$

where: α is a volume residual and a function of P and T.

Another form of equation 183 shows clearly the difference between the volume residual type of equation-of-state and the perfect gas law equation and also the similarity with equations 163 and 170 of Parts VIII. This form is found by multiplying equation through by P, giving

$$PV = RT - \alpha P \qquad (184)$$

In this equation α P is the correction to the perfect gas isotherm.

Another form of equation 183 may be found by solving for pressure, which gives

$$P = \frac{RT}{V + \alpha} \qquad (185)$$

This is not a very satisfactory "explicit-in-pressure" equation. If an "explicit-in-pressure" equation is to be used, there should be a $T = 0$ intercept term in the equation which would modify equation 185 and change the definition of α. It would then be a different residual.

From the above it is evident that equation 183, with α as a function of P and T, is the most convenient way to use this volume residual. Deming and Shupe[4] used this α volume residual and equation 183 in deriving thermodynamic properties for several gases. These authors used graphical methods of getting the volume derivative, plotting α against temperature for different pressures for the graphical differentiation.

The writer[8] used the reduced volume residual, α_r in correlating the P-V-T data for hydrocarbons. A reduced generalized equation of state is obtained from equation 180 by replacing the various terms by their equivalents, $\alpha = \alpha_r \alpha_c$, $P = P_r P_c$, and $T = T_r T_c$, giving

$$\frac{V}{\alpha_c} = \frac{(RT_c)}{(P_c \alpha_c)} \frac{T_r}{P_r} - \alpha_r \qquad (186)$$

where: α_r is a function of T_r and P_r and the ratio $(RT_c/P_c\alpha_c)$ is a different constant for each component.

The critical volume residual is found from the critical volume by the expression $\alpha_c = \frac{RT_c}{P_c} - V_c$.

P-V-T data on eleven hydrocarbons were collected and correlated by this method in 1938.[8] This correla-

tion is given as Figure 20, which first appeared in the article referred to above. This correlation was the basis for thermodynamic deviations to get the isothermal effects of pressure on the entropy, enthalpy, etc.

Figure 20 is more precise than Figure 19, as was pointed out in the author's 1938 article where maximum deviations between observed and predicted volumes were given and compared with the maximum deviations for the compressibility plot. It is customary to use both average and maximum deviations to define the accuracy of such a correlation. Average deviations alone are often misleading because the positive deviations could offset the negative deviations. Maximum deviations are a more severe test of a P-V-T correlation. Accordingly, the author compared the α_r with the Z correlation by means of maximum deviations. For the compressibility plot (Figure 19) the maximum deviation of calculated volume from observed (experimental) volumes is 14.5 percent as compared with 9.8 percent for α_r (Figure 20). The average of the maximum deviations for these two correlations for eleven hydrocarbons was found to be 8 percent for the PV/RT and 5 percent for the α_r correlation.

In figuring these deviations, positive and negative differences were included with no regard for sign. Often the maximum deviation for one correlation was at different T_r and P_r conditions than for the other, both being for the same hydrocarbon, of course.

Deming and Shupe[4] also used another volume residual which also shows the departure from the perfect gas. This other residual is a function of the compressibility factor and is given by the following equation

$$\Delta = V\left(\frac{PV}{RT} - 1\right) \qquad (187)$$

Equation 187 is not explicit in volume, but is explicit in pressure. Rearranging gives

$$PV = RT\left(1 + \frac{\Delta}{V}\right) \qquad (188)$$

The Δ/V term is a correction to the PV isotherm, differing from the other PV isotherm correction discussed previously. Solving for P gives the following "explicit-in-pressure" equation that is more logical than the one obtained from the volume residual, α.

$$P = \frac{RT}{V}\left(1 - \frac{\Delta}{V}\right) \qquad (189)$$

Another volume residual is found by dividing equation 183 thru by V and solving for α/V, which will be called β giving

$$\beta = \frac{\alpha}{V} = \left(\frac{RT}{PV} - 1\right) \qquad (190)$$

This volume residual has the advantage of not being too large at low pressures. The volume residual, β, is a function of P and T and can be correlated graphically.

Solving equation 190 for PV gives

$$PV = \frac{RT}{\beta + 1} \qquad (191)$$

Equation 191 is explicit in pressure or volume, which makes it more convenient than equation 188.

Pressure Residuals

Another residual method that has been used with P-V-T data is the pressure residual used by York[28] in correcting for the departure from straight line isometrics. This can be a very powerful method because of the small magnitude of the pressure residual. However, it requires additional correlations for the isometric slopes and intercepts.

With a pressure residual equation 172 would become

$$P_r = M'T_r - B' - R_p \qquad (192)$$

Where: R_p is a reduced pressure residual which is a function of T_r and V_r.

Equation 192 is explicit in P_r with M′ and B′ functions of V_r and T_r. This equation would not be applicable to all hydrocarbons as it stands unless an additional factor were included bringing the same isometrics for different components together.

In the next installment the pseudo-critical concept will be discussed and correlations presented for estimating the pseudo-critical of hydrocarbon mixtures. Also the relation between the pseudo-critical concept and the combination of individual equation of state constants for mixtures will be discussed. A few literature references on this subject are included [11, 19, 22, 23] for those interested.

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(End of Part IX. Part X will appear in the April issue.)

Preparation and Properties of High Viscosity Index Motor Oils

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DURING recent years we have become accustomed to use a number of natural and synthetic polymeric products both for improving older materials or methods of construction as well as for obtaining entirely new articles. The relatively new and rapidly expanding field of polymer chemistry and the extent of the plastics and synthetic rubber industries is impressive evidence of the importance of this subject of investigation. It seems only natural that attention directed to the study of oil soluble polymeric materials should provide new applications and improvements in the petroleum industry.

By means of a polymethacrylate viscosity index improver it is possible to produce oils which fulfill the viscosity requirements of two or more SAE viscosity grades with considerable simplification of the number of motor and gear oil grades required. The desirability of having a flexible means of controlling viscosity and viscosity index has long been generally recognized.

This material was presented at the Society of Automotive Engineers National Fuels and Lubricants meeting in Tulsa last November.

ONE of the first applications of oil soluble polymers was for improving the viscosity-temperature characteristics of motor oils. This is a use for which certain polymers are admirably suited. Dissolving polymeric materials in a suitable solvent has long been known as a means of obtaining fluids of excellent viscosity-temperature characteristics, and the addition of polymers to petroleum oils can be used to obtain hydrocarbon fluids having viscosity characteristics so fine as to compare favorably with special synthetic fluids. This is somewhat analogous to the familiar blending of a heavy bright stock with a light oil to improve the viscosity index as well as to thicken the oil except that in this case the polymer may be considered as a super bright stock.

As a result of the development of some of these polymeric materials before the war, it was possible to make rather quickly the necessary modifications for the production of polymers best suited for preparing the special hydraulic fluids used extensively during the war. Oil soluble polymethacrylates[1] supplied to the industry as oil solutions were thus developed for preparation (in combination with suitable petroleum base stocks) of aircraft hydraulic fluids and for oils useful as combination hydraulic oils and gear lubricants. Polybutene[2] was similarly useful for preparing special recoil and gear oils. These fluids were instrumental in making possible the operation of equipment at tropical temperatures as well as at -65° F. or -75° F. The familiar viscosity index scale giving values of 200 and 300 was inadequate for describing the viscosity—temperature characteristics of these special fluids. Other systems, such as the ASTM slope, viscosity temperature coefficient and the Hardiman—Nissan[3] viscosity index scale, were also tried but with only fair success.

Loss of Viscosity

With oil blends of these polymers the intense shearing action imposed by hydraulic pumps and relief valves operating at high pressures and at high rates is sufficient in some instances to cause partial breakdown of the high molecular weight polymers to a lower molecular weight thus causing a permanent loss of viscosity of the fluid. When a given fluid is prepared with a high molecular weight polymer, the loss in viscosity is greater than when a low molecular weight polymer is used. But since the higher molecular weight polymers produce a greater improvement of viscosity—temperature behavior for a given weight of polymer, it is advantageous to use polymers having as high a molecular weight as practical without resulting in excessive shear breakdown.

An important property that distinguishes between the various possible polymer types available is the relationship between the improvement in the viscosity—temperature characteristics obtained and the stability to shear of the polymer. Closely related to the improvement of viscosity—temperature characteristics is the ability of a particular polymer to produce the desired improvement without causing excessive thickening of the oil. Certain polymethacrylates appear outstanding in this regard since by comparison with other polymers they produce the greatest viscosity index improvement for a given amount of polymer with the least increase in viscosity and with the greatest stability to mechanical shear.

The recognized advantages of having oils showing the least change in viscosity with change in temperature have caused much effort to be directed toward methods for obtaining both synthetic and natural oils which possess the best viscosity—temperature characteristics. Production of oils with increasingly higher viscosity indices has been one of the aims of modern petroleum extraction procedures. While many extraction techniques improve the viscosity index and produce motor oils causing a minimum of engine deposits, they also remove components which are desirable as inhibitors. They are practical limits to the amount of viscosity index improvement obtainable by solvent extraction of petroleum oils. Moreover, the lube oil yield is reduced by extensive extraction. In some instances it may be more practical to use only sufficient extraction to remove undesirable components from lube oils and to depend on the use of a viscosity index improver to obtain the desired viscosity characteristics. Viscosity index improvers may be used to raise the viscosity index of low V-I stocks to equal or surpass the viscosity characteristics of extracted stocks as well as

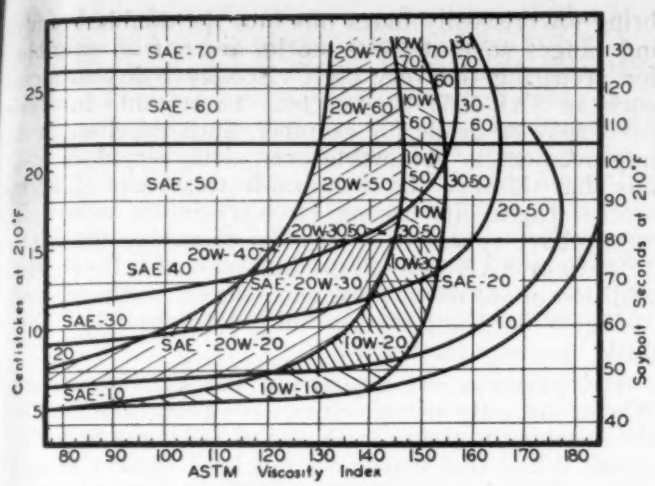

Figure 1. Viscosity. Viscosity index requirements for combining SAE motor oil grades as determined by straight line extrapolation on ASTM D341-41.

further to improve the viscosity—temperature properties of extracted or of high grade stocks. In connection with the addition of a viscosity index improver to low V-I stocks, it should be remembered that the V-I improvement obtained in this way does not necessarily improve the stability to oxidation or reduce engine deposits that may be characteristic of low grade stocks.

For appropriate stocks the additional viscosity index improvement required for double branding in the most commonly used SAE viscosity grades of motor oil is easily obtained by means of suitable oil soluble polymethacrylates. Combining two or more of the SAE viscosity grades with simplification of storage and maintenance problems as well as obtaining the other desirable properties of high viscosity index motor oils would appear to be an important application of these polymeric viscosity index improvers.

By plotting the viscosity at 210° F. versus the viscosity index, it is possible to show the combinations of viscosity and viscosity index which produce double-branded and in some cases triple-branded oils, as shown in Figure 1 for motor oils and in Figure 2 for gear oils. These charts were obtained simply by plotting the various SAE specification viscosity limits on ASTM viscosity-temperature chart D341-41 and calculating the viscosity index values for blends

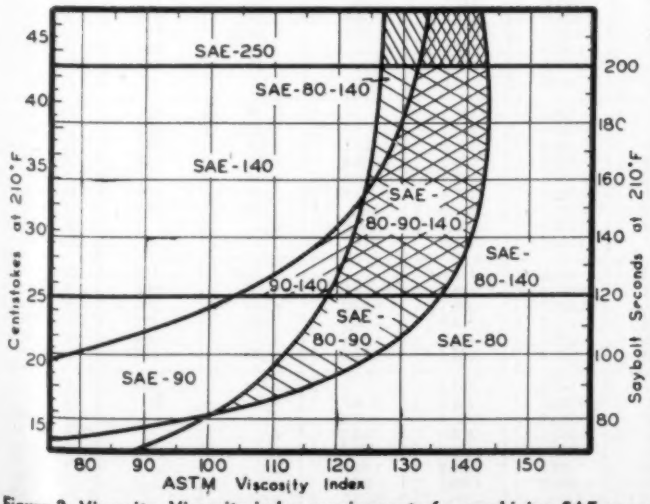

Figure 2. Viscosity. Viscosity index requirements for combining SAE gear oil grades as determined by straight line extrapolation on ASTM chart D341-41.

having the limiting viscosities. Some overlapping occurs because of peculiarities of the SAE grading system; particularly regarding the SAE-40 grade which has a minimum viscosity specified at 130° F. and a maximum at 210° F. It was noted when this chart was prepared, as shown in Figure 3 using the Hardiman and Nissan Viscosity Index scale, instead of the ASTM scale, that there was much less dependence of the viscosity index on the viscosity of the blend. Thus, for the more viscous oils, the Hardiman and Nissan viscosity index values increase in a more regular manner than the ASTM values particularly above 130 viscosity index. Most useful are those oils having sufficiently high viscosity indices to meet the requirements of a winter oil as well as of a heavier oil such as the combination of SAE LOW-10, LOW-20, 20W-30 or 10W-30. Comparison of the viscosities of present day motor oils shows that only two double-

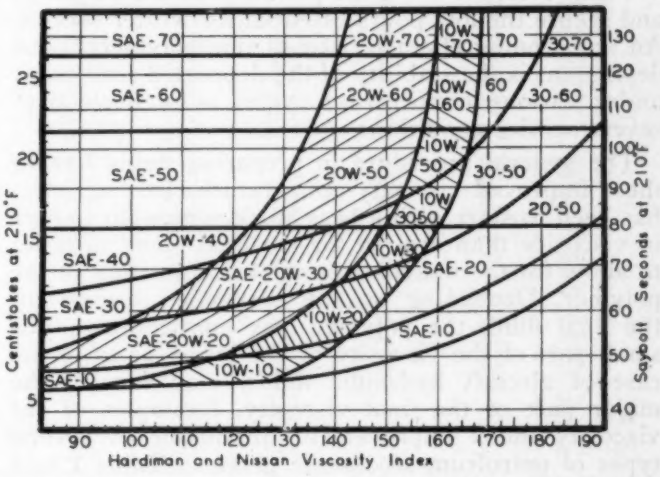

Figure 3. Requirements for combining SAE motor oil grades using the Hardiman and Nissan viscosity index scale and straight line extrapolations on ASTM chart D341-41.

branded oils—SAE LOW-20 and SAE 20W-30 would fulfill the requirements of the major portion of automotive engine oils. Similarily, gear oils which fulfill the requirements for SAE 90-140 and SAE 80-90-140 grades can be prepared using polymethacrylate viscosity index improvers.

At high temperatures the viscosities of these double-branded oils are higher than for the usual oils of the same viscosity at 210° F. for example. As a matter of fact, if the double-branded oils are adjusted to have viscosity and viscosity index values in the upper part of the region for double-branding, then they are equivalent in viscosity at high temperatures to the usual oils in the next higher SAE viscosity range. The SAE 10W-30 range is particularly interesting because such an oil can serve as an all season motor oil and only this one grade would serve the needs of most motor car service. A synthetic motor oil[4] has already been placed on the market which because of its high viscosity index and low pour point is suitable for year-round lubrication. Oil soluble polymethacrylates in petroleum base stocks offer a very flexible means of obtaining almost any viscosity together with the very high viscosity index. Generally the cost of such blends, particularly those having properties sufficiently improved to be of the greatest practical interest, can be obtained more economically by addition of small amounts of polymer. These petroleum base-polymer blends have the advantage of possessing low temperature viscosi-

ties nearly the same as predicted by straight-line extrapolation on ASTM viscosity-temperature charts while some synthetic oils show a pronounced thickening at low temperatures.

Since these double-branded oils combine the properties of a winter grade as well as a heavier oil, it is necessary that the pour point of the oils be low, and that the polymer remains completely soluble under all conditions. Usually a pour depressant is used to obtain the low pour point. Fortunately for the purpose of preparing high viscosity index motor oils, certain polymethacrylates[5] have been found to be powerful pour depressants while also being excellent viscosity index improvers. Since the viscosity index improving characteristics of these pour depressant polymers are very nearly as good as for the polymers preferred for this purpose alone, it is thus possible to obtain either a part or all of the desired V-I improvement using the pour depressant polymers and secure the low pours essential for winter service. An outstanding characteristic of this polymeric pour depressant is the stability of the depressed pour point under various temperature cycles as well as after severe service conditions.

The general procedure in preparing fluids having these improved viscosity-temperature characteristics has been to start with a base stock somewhat lighter in viscosity than desired for the final blend in order to allow for the unavoidable thickening action of the polymer. Depending on the properties desired for the final fluid, the polymer may contribute only a small part of the viscosity of the blend, or as in the case of aircraft hydraulic fluids, may furnish the major part of the final viscosity. Examples of the viscosity index improvement obtainable in several types of petroleum stocks are given in Table 1 to 5 for an oil soluble polymethacrylate available for this purpose[6]. Both low and high viscosity index stocks have been included in these few examples. It is to be expected of course that more polymer is required to bring low viscosity index oils into the double-branding ranges so that these stocks are not as suitable for preparing the very high viscosity index grades, such as SAE-10W-30, but may be suitable for the SAE 20W-30 grade for example. Such excellent V-I improvement is obtainable even with very low V-I oils that this may be a desirable treatment of such stocks. Light oils having viscosity index values of 90 or above appear to be best for preparing the SAE 10W-20 or SAE 10W-30 grades since with these, the addition of sufficient polymer to produce the desired V-I gain does not thicken the oil beyond the SAE 10W viscosity limit at 0° F.

For purposes of comparison the Hardiman and Nissan viscosity index values have been indicated in these tables together with the ASTM viscosity indices. While this scale may not be a perfect means of expressing viscosity-temperature characteristics, it retains the convenience of the familiar Dean and Davis scale but is much less dependent on the viscosity of the blend at values above 13° such as are readily obtained with these polymer blends.

The various base stocks used for obtaining these viscosity data were arbitrarily selected, but for preparing a particular blend having a certain viscosity and viscosity index, it is desirable to determine the minimum amount of polymer required. This can be determined by using viscosity data of this sort and simple graphical procedures. For a series of neutral —bright stock—polymethacrylate blends, for example, the blends possessing the desired viscosity index are selected and the viscosities of these are plotted against the polymer concentration. In this way the composition of the blend having the desired viscosity as well as viscosity index can be determined. This blend will have the minimum amount of polymer needed to produce the required viscosity index improvement and the maximum amount of bright stock that can be used as thickener.

The relative molecular weight of the polymer

TABLE 1

Viscosity Data on ACRYLOID 710 in Blends of Extracted Pennsylvania 150 Neutral and 140 Bright Stock

BASE STOCK							VISCOSITY INDEX					
Weight Percent Neutral	Weight Percent Bright Stock	Weight Percent Polymer	210° F.		100° F.				Percent Viscosity Increase at 210° F.	130° F. (Interpolated)		SAE Grade
			Cs.	S.U.S.	Cs.	S.U.S.	ASTM	H & N		Cs.	S.U.S.	
94	6	0.0	5.709	44.9	36.44	174.2	105.9	105.5	.....	18.5	91	10W-10
		0.2	6.034	45.9	38.27	177.9	112.2	110.7	5.7	20	98	10W-10
		0.4	6.382	47.1	40.02	185.8	118.5	115.1	11.8	21	102	10W-10
		0.8	7.116	49.4	44.11	204.3	126.9	122.1	24.7	23	111	10W-10
		1.6	8.820	55.2	53.37	246.9	136.8	133.0	54.4	28.5	135	10W-20
		2.4	10.70	61.6	63.73	294.5	141.2	139.6	87.5	34.5	161	10W-20
		3.2	13.42	71.7	80.15	370.3	142.9	144.8	153.	44	204	10W-30
		4.0	16.09	87.0	95.38	440.6	143.5	148.7	180.	55	255	20W-30-50
		5.0	19.31	95.3	114.7	529.9	143.5	151.0	238.	..	....	20W-50
78	22	0.0	7.352	50.21	52.66	243.6	108.8	107.1	.....	26	124	20W-20
		0.2	7.740	51.5	54.84	253.7	113.8	110.7	5.3	27.5	130	20W-20
		0.4	8.170	52.9	57.22	264.6	118.1	115.0	11.1	29	137	20W-20
		0.8	9.000	55.8	62.51	288.9	123.3	120.2	22.4	31	146	20W-20
		1.6	10.94	62.5	73.95	341.6	131.3	132.0	48.8	38	177	20W-20
		2.4	13.05	70.2	87.07	402.3	135.5	136.6	77.6	45	209	20W-30
		3.2	16.09	82.0	108.2	499.9	137.1	140.6	119.	57	264	20W-50
		4.0	18.79	93.1	123.9	568.7	138.9	145.2	156.	..	....	20W-50
		5.0	23.33	112.5	151.9	703.	139.2	148.9	218.	..	....	20W-60
58	42	0.0	10.38	60.6	88.28	407.8	107.3	105.6	.....	40.5	188	20W-30
		0.2	10.89	62.4	92.38	426.8	110.0	108.2	4.9	44	204	20W-30
		0.4	11.44	64.3	96.00	443.5	113.2	112.7	10.2	45	209	20W-30
		0.8	12.53	68.3	104.2	481.4	117.1	116.6	20.7	49	227	20W-30
		1.6	14.99	77.7	118.3	546.5	125.9	128.0	44.4	57	264	20W-40
		2.4	17.73	88.7	140.4	648.6	128.8	131.8	71.8	69	319	20W-50
34	66	0.0	15.47	79.6	164.1	758.	102.9	103.4	.....	72	334	40
		0.2	16.20	82.5	169.5	783.	105.9	107.0	4.7	..	....	50, 80
		0.4	16.83	85.0	173.8	803.	108.8	110.1	8.8	..	....	50, 80-90
		0.8	18.29	91.0	184.9	854.	113.2	115.0	18.2	..	....	50, 80-90
		1.6	21.43	104.3	210.4	972.	119.1	122.9	38.5	..	....	50, 80-90
		2.4	25.12	120.3	238.3	1101.	123.5	128.9	62.4	..	....	60, 80-90
		3.2	28.92	137.1	254.4	1175.	128.2	136.7	87.	..	....	70, 80-90
												140
		4.0	33.56	157.8	298.7	1380.	128.2	138.7	117.	..	....	80, 90-140
		5.0	39.75	185.9	346.4	1612.	129.1	141.1	157.	..	....	80-140

used was such that a thirty weight percent solution in toluene had a viscosity of 160 centistokes at 100° F. Of course a similar polymer of higher molecular weight would give even greater viscosity index improvement, but in actual use it would be found to show more pronounced viscosity loss under severe shearing conditions. Also, somewhat larger amounts of a lower mole-weight polymer would be required to obtain a given V-I improvement, but mechanical stability of this polymer would be even better. With the molecular weight for which the examples are given, noticeable mechanical depolymerization has been found only in severe engine tests in which thickening of the base stock by oxidation was minimized by using high grade, well inhibited oils. When used under what might be called typical driving conditions, the presence of the polymer has a sort of viscosity stabilizing effect since the thickening of the oil as a result of oxidation is compensated in part by the viscosity decrease resulting from mechanical working of the polymer.

The presence of these polymers in a motor oil appears to cause no unusual effect as far as oxidation stability of the oil blend is concerned. These materials

TABLE 2

Viscosity Data on ACRYLOID 710 in Extracted Mid-Continent Stocks

BASE STOCK			210° F.		100° F.		VISCOSITY INDEX		Percent Viscosity Increase at 210° F.	130° F. (Interpolated)		SAE Grade
Weight Percent Neutral	Weight Percent Bright Stock	Weight Percent Polymer	Cs.	S.U.S.	Cs.	S.U.S.	ASTM	H & N		Cs.	S.U.S.	
90	10	0.0	6.183	46.4	38.73	179.9	115.9	113.5	....	21	102	10W-10
		0.2	6.550	47.6	41.10	190.6	120.0	115.8	5.8	22	106	10W-10
		0.4	6.916	48.7	42.78	198.6	125.8	121.0	11.8	24	115	10W-10
		0.8	7.663	51.2	46.67	216.0	131.8	126.9	24.0	25	119	10W-10
		1.6	9.400	57.2	55.67	257.5	139.8	136.5	51.9	30	141	10W-20
		2.4	11.25	63.6	64.95	300.1	143.7	142.1	81.2	35	164	10W-20
		3.2	13.69	72.7	76.85	355.	146.6	148.6	121.4	42	195	10W-30
		4.0	16.00	81.7	89.33	413.	146.7	152.0	159.0	48	223	10W-30-50
		5.0	19.30	95.2	106.3	491.	145.5	155.0	212.5	60	278	20W-50
72	28	0.0	8.038	52.5	58.83	272.0	111.7	109.3	....	29	137	20W-20
		0.2	8.300	53.4	59.87	276.8	115.8	112.1	3.2	30	141	20W-20
		0.4	8.750	54.9	62.28	287.9	119.8	116.2	8.9	31	146	20W-20
		0.8	9.768	58.4	67.28	310.9	126.9	124.4	21.5	35	164	20W-20
		1.6	11.69	65.2	78.29	361.7	133.7	132.7	45.4	40	186	20W-30
		2.4	13.88	73.5	90.90	420.0	137.3	139.1	72.8	46	213	20W-30
		3.2	16.84	85.1	107.1	495.	140.2	145.1	109.9	57	264	20W-50
		4.0	19.70	96.9	122.8	567.3	141.1	149.1	145.1	....	....	20W-50
		5.0	23.71	114.1	145.2	671.	141.2	152.9	195.1	....	....	20W-60
54	46	0.0	11.03	62.8	92.63	428.1	111.5	110.8	....	45	209	20W-30
		0.2	11.54	64.7	95.83	442.9	114.4	114.5	4.6	46	213	20W-30
		0.4	12.11	66.8	99.38	459.1	117.3	117.0	9.8	47	218	20W-30
		0.8	13.25	71.0	106.9	493.9	121.3	122.2	20.1	53	246	20W-30
		1.6	15.67	80.4	122.4	565.5	127.4	129.8	42.1	60	278	20W-50
		2.4	18.45	91.7	139.7	645.5	131.8	136.0	67.3	....	....	20W-50
		3.2	20.98	102.3	151.2	698.5	135.0	142.1	90.1	....	....	20W-50-80
		4.0	24.33	116.8	172.5	797.	135.9	145.2	120.6	....	....	20W-60
		5.0	28.65	135.9	199.3	921.	136.3	148.5	159.9	....	....	80-90-140
35	65	0.0	16.97	85.6	178.6	825.1	107.4	108.1	....	....	....	50-80-90
		0.2	17.70	88.6	184.3	851.3	109 8	112.8	4.3	....	....	50-80-90
		0.4	18.52	91.9	190.4	879.6	112.3	113.5	9.1	....	....	50-80-90
		0.8	19.77	97.2	200.2	924.9	115.2	119.6	16.5	....	....	50-80-90
		1.6	23.20	113.9	224.9	1039.0	122.6	126.1	36.7	....	....	60-80-90
		2.4	26.76	127.5	253.8	1172.6	124.3	130.9	57.6	....	....	70-80-90 140

TABLE 3

Viscosity Data on ACRYLOID 710 in Mixed Base Oils

BASE STOCK			210° F.		100° F.		VISCOSITY INDEX		Percent Viscosity Increase at 210° F.	130° F. (Interpolated)		SAE Grade
Weight Percent Neutral	Weight Percent Bright Stock	Weight Percent Polymer	Cs.	S.U.S.	Cs.	S.U.S.	ASTM	H & N		Cs.	S.U.S.	
94	6	0.0	5.607	44.6	37.54	175.8	90.9	95.5	....	18.3	91	10
		0.2	5.981	45.8	40.05	185.9	101.8	101.9	6.7	20.	98	10
		0.4	6.341	46.9	42.21	195.6	108.0	106.2	13.1	20.8	101	10
		0.8	7.137	49.5	47.08	218.1	118.6	115.6	27.3	24.5	117	10
		1.6	8.945	55.6	57.42	265.5	130.4	128.0	59.5	30.	141	20W-20
		2.4	11.05	62.8	69.65	321.8	137.4	137.8	97.1	36.5	170	20W-20
		3.2	14.39	75.4	93.52	431.9	138.1	140.4	156.5	49.	227	20W-30
		4.0	17.20	86.5	111.1	513.3	139.7	144.1	206.2	58.	269	20W-50
		5.0	20.96	102.3	134.2	620.0	140.0	148.0	274.0	....	....	20W-50
72	28	0.0	7.712	51.4	61.13	287.2	97.7	96.4	....	29.	137	20W-20
		0.2	8.159	52.9	64.17	296.6	103.2	100.9	5.8	31.	145	20W-20
		0.4	8.615	55.5	67.57	312.3	107.2	105.3	11.7	33.	154	20W-20
		0.8	9.616	57.9	73.90	341.4	114.2	113.1	24.7	36.	168	20W-20
		1.6	11.83	65.8	83.69	409.8	124.8	124.3	53.4	44.	204	20W-30
		2.4	14.36	75.3	105.3	486.4	130.3	127.7	86.1	53.	245	20W-30
		3.2	18.25	90.9	137.9	637.0	131.6	136.3	136.9	68.	315	20W-50
		4.0	21.07	102.7	156.5	723.0	133.7	140.3	173.4	....	....	20W-50
		5.0	25.64	122.5	188.0	868.6	134.8	144.1	232.9	....	....	20W-60
56	44	0.0	9.712	58.2	87.09	402.4	97.6	96.4	....	39.	181	20W-20
		0.2	10.25	60.1	91.46	422.6	101.3	100.8	5.5	42.	195	20W-30
		0.4	10.78	61.9	95.67	442.1	104.4	103.5	10.0	45.	208	20W-30
		0.8	11.93	66.1	104.2	481.49	110.7	110.0	22.8	50.	231	20W-30
		1.6	14.43	75.6	122.7	566.9	119.7	120.0	48.6	57.	264	20W-40
		2.4	17.31	87.0	142.7	659.3	125.8	127.2	78.2	....	....	20W-50
28	72	0.0	15.45	79.5	178.6	825.	94.8	94.9	....	....	....	40
		0.2	16.23	82.6	185.7	858.	98.2	99.3	5.0	....	....	50, 90
		0.4	16.87	85.2	191.3	884.	100.8	102.1	9.2	....	....	50, 90
		0.8	18.38	91.4	204.5	945.	106.1	107.2	19.0	....	....	50, 90
		1.6	21.72	105.5	233.7	1080.	113.7	114.2	40.6	....	....	60, 90
		2.4	25.41	121.5	266.1	1229.	118.5	122.2	64.1	....	....	60, 90-140
		3.2	31.11	146.8	318.6	1472.	122.2	129.3	101.3	....	....	70, 90-140
		4.0	35.66	167.4	358.4	1658.	124.8	133.1	131.0	....	....	140
		5.0	41.86	194.0	406.1	1874.	126.2	138.2	171.0	....	....	.....

being polymeric esters are relatively inert. They can not readily be hydrolyzed and are apparently less susceptible to oxidation than petroleum oils. Oxidation and bearing corrosion tests such as obtained on Underwood machines and by modified Indiana type oxidation tests have shown that the various commercial oxidation-bearing corrosion inhibitors function the same when the polymers are present in the blend as with only the base oil.

Engine tests are perhaps of greatest interest for evaluating motor oils and a numer of 36 hour type L-4 Chevrolet engine tests as well as hundreds of thousands of miles of road tests have been made on these polymer-containing high viscosity index oils using several base stocks. Engine ratings on some of these tests are given in Table 6. It was found that with a given set of test conditions the final engine rating was determined by the grade of oil stock and the inhibitors used rather than by the presence of the polymers. Although such engine tests are usually made to determine the condition of the engine after using a given oil, for the polymer in oil blends the effects of the engine test on the oil are perhaps of greater interest. Since the polymers are added primarily for their effect on viscosity and pour point of the oil, the changes in these properties reflects the behavior of the polymer. In an engine test changes in viscosity of these high viscosity index test oils can result from oxidation of the oil, which usually causes thickening of the blend, or from deterioration of the polymer either from oxidation or mechanical breakdown. It is difficult to separate these effects directly although by comparison of oxidation tests made on the base stocks as well as on the polymer blends and by comparing the effects of adding fresh polymers to partially oxidized oils, it was found that oxidation

TABLE 4

Viscosity Data on ACRYLOID 710 in Mixed Base Oils

Weight Percent Polymer	210° F.		100° F.		VISCOSITY INDEX		Percent Viscosity Increase at 210° F.	130° F. (Interpolated)		SAE Grade
	Cs.	S.U.S.	Cs.	S.U.S	ASTM	H & N		Cs.	S.U.S.	
0.0	5.556	44.4	44.64	211.	50.4	61.5	....	21	102	10
0.2	5.999	45.8	48.22	223.	65.2	72.0	8.0	23	110	10
0.4	6.442	47.3	51.74	239.	75.4	79.2	15.9	24.5	117	10
0.8	7.437	50.5	59.28	274.	93.7	93.6	33.9	28	132	20W-20
1.6	9.627	57.9	76.19	352.	112.	110.1	73.4	37	172	20W-20
2.4	12.26	67.3	96.70	447.	121.2	120.5	120.6	47	218	20W-30
0.0	6.976	49.0	65.99	305.	54.5	57.9	....	29	136	20
0.2	7.554	50.9	71.13	329.	67.6	68.9	8.3	32	150	20
0.4	8.067	52.6	75.97	351.	75.2	74.7	15.6	34	159	20
0.8	9.244	56.6	85.88	397.	88.2	88.4	32.2	39	181	20
1.6	11.78	65.6	108.7	502.	104.8	104.2	69.0	50	231	30
2.4	14.99	77.7	136.5	631.	115.1	116.0	114.8	63	291	40
0.0	10.44	60.8	130.1	601.	56.2	53.6	....	51	236	30
0.2	11.14	63.2	138.0	638.	63.4	61.9	6.7	55	254	40
0.4	11.87	65.9	146.3	676.	69.7	69.2	13.8	59	273	40
0.8	13.37	71.5	162.8	752.	80.4	80.0	28.0	67	309	40
1.6	16.85	85.1	200.7	927.	96.2	96.9	61.3	....	....	50, 90
2.4	20.72	101.2	243.3	1124.	105.9	106.6	99.3	....	....	50, 90
0.0	15.84	81.0	250.0	1155.	60.3	59.4	....	....	....	50
0.2	16.76	84.7	264.6	1223.	65.0	64.8	5.8	....	....	50
0.4	17.78	88.9	277.4	1282.	71.1	70.0	12.2	....	....	50, 90
0.8	19.90	97.8	305.6	1412.	80.6	80.0	25.6	....	....	50, 90
1.6	24.61	113.7	369.9	1711.	94.8	94.0	55.3	....	....	60
2.4	30.62	144.7	439.7	2016.	104.9	107.8	93.3	....	....	70, 140
0.0	21.65	105.2	411.2	1900.	63.3	61.2	....	....	....	60
0.2	22.97	111.0	431.6	2000.	69.2	66.2	6.1	....	....	60
0.4	24.31	116.7	450.9	2090.	74.1	72.0	12.3	....	....	60
0.8	26.89	128.1	492.3	2280.	81.8	79.7	24.2	....	....	70, 140
1.6	32.69	153.9	581.7	2695.	93.2	92.0	51.0	....	....	140
2.4	39.16	183.2	674.5	3120.	101.4	99.0	80.9	....	....	140

TABLE 5

Viscosity Data on ACRYLOID 710 in Naphthenic Stocks

	Weight Percent Polymer	210° F.		100° F.		VISCOSITY INDEX		Percent Viscosity Increase at 210° F.	130° F. (Interpolated)		SAE Grade
		Cs.	S.U.S.	Cs.	S.U.S.	ASTM	H & N		Cs.	S.U.S.	
Base Oil 200 Pale Oil	0.0	5.346	44.2	49.40	229.	13.1	21.5	....	22	102	10
	0.2	5.737	45.0	50.76	235.	33.16	44.4	7.3	23	106	10
	0.4	6.249	46.6	54.48	252.	53.59	59.7	16.9	25	115	10
	0.8	7.177	49.5	62.71	290.	74.46	75.3	34.2	29	134	20
	1.6	9.367	57.1	80.70	373.	100.5	98.3	75.2	38	175	20
	2.4	11.58	64.8	101.5	469.	109.1	108.2	116.3	48	222	30
500 Pale Oil	0.0	8.550	54.3	112.9	520.	20.0	24.6	....	45	208	30
	0.2	9.308	56.9	120.5	557.	36.38	35.0	8.9	48	222	30
	0.4	9.979	59.1	128.6	594.	45.65	45.3	16.7	52	240	30
	0.8	11.25	63.6	143.8	664.	59.6	59.6	31.6	58	268	40
	1.6	14.43	75.6	178.7	826.	83.5	83.2	68.7	75	346	40
	1.6	14.43	75.6	178.7	826.	83.5	83.2	68.7	75	346	40
	2.4	17.96	89.7	216.4	1000.	98.16	98.3	110.0	90	416	50, 90
750 Pale Oil	0.0	10.15	59.7	165.5	765.	1.76	20.3	....	60	277	40
	0.2	10.91	62.4	176.9	818.	13.97	13.14	7.5	65	300	40
	0.4	11.65	65.1	189.1	874.	22.83	22.75	14.8	70	324	40
	0.8	13.22	70.9	209.0	966.	42.66	44.5	30.2	78	360	40
	1.6	16.96	85.5	261.1	1206.	68.99	68.9	67.1	100	462	50
	2.4	21.10	102.8	313.8	1450.	87.0	86.1	107.9	122	560	50, 90
1200 Pale Oil	0.0	12.63	68.7	266.4	1231.	−18.6	−16.6	....	90	416	40
	0.2	13.41	71.6	282.5	1305.	− 8.46	− 5.5	6.2	95	438	40
	0.4	14.26	74.9	298.0	1377.	2.6	4.0	12.9	100	462	40
	0.8	16.22	82.6	327.4	1513.	25.9	27.7	28.4	112	518	50
	1.6	21.03	102.4	400.7	1852.	60.84	59.4	66.5	143	662	50
	2.4	25.63	122.8	480.7	2250.	76.70	73.6	102.9	170	786	60, 140

of the polymethacrylates was of less importance than oxidation of the base oil or of mechanical depolymerization of high molecular weight polymers. Oxidation of the oil during an engine test can be minimized by avoiding unusually high temperatures, yet the mechanical shear action of the oil is probably the same. The shearing action of the engine on the oil is presumably determined by the fitting of the parts, the load and engine speed although of course even various new or reconditioned engines, although of the same model, may have slightly different bearing or piston clearances which may have considerable effect on the intensity of the shearing action.

A Chevrolet engine test found useful for evaluating the intensity of the shearing action on the polymer blends without causing excessive oil oxidation was made using a jacket temperature of 160° F. and a speed of 2465 rpm instead of 200° F. and 3150 rpm respectively. Running this test for 40 hours gave mileage equivalent to the 36 hour higher speed test. Road tests on the same polymer blends gave results very similar to this engine test. Example of such tests obtained with an SAE 10W-20 blend are given in Table 7. This particular blend was prepared using a well inhibited, highly extracted mid-continent oil and a total of two percent oil soluble polymethacrylates were added to obtain an initial viscosity index of 140 as well as a pour point of -35° F.

Some road test data given in Table 7 have been selected from cars using but little oil so that the full effects of the engine would be apparent. With this high quality inhibited base stock, there was little oxidation of the oil and some mechanical breakdown of the polymers was noticeable as resulting in a decrease in viscosity and viscosity index. For practical purposes these changes are small and when some make up oil is added, as is usually necessary with the "average" car between oil changes, the viscosity of the oil shows negligible change from only this factor. Much greater change by far results from gasoline dilution of crankcase oils.

This brief discussion has mentioned some of the main features of incorporating suitable oil soluble polymethacrylates in petroleum stocks for the purpose of obtaining greatly improved viscosity-temperature characteristics as well as low pour point. The desirability of having a very flexible means of controlling viscosity and viscosity index has long been generally recognized. By means of a polymethacrylate viscosity index improver it becomes possible to produce oils which fulfill the viscosity requirements of two or more SAE viscosity grades with considerable simplification of the number of motor and gear oil grades required.

TABLE 6
Chevrolet Engine Test Data on High Viscosity Index ACRYLOID Blends

Base Oil: 89.41 percent Barosa 43 Extracted 150 Neutral
9.94 percent Barosa 120 Extracted 120 Bright Stock
0.75 percent Santolube 394C

	36-Hour L-4 Test			40 Hour L-4 Special Test
	Barosa SAE-10 Base Stock 0.75 Percent Santolube 394C	Base Stock Plus ACRYLOID 710/150 for V.I. 125 SAE-10W-10	Base Stock Plus ACRYLOID 710/150 for V.I. 140 SAE-10W-20	Base Stock Plus ACRYLOID 710/150 for V.I. 140 SAE-10W-20
Varnish Deposits				
Piston Skirts	6.8	6.7	6.4	9.4
Rocker-Arm Cover Plate	10.0	10.0	10.0	10.0
Push-Rod Cover Plate	10.0	10.0	10.0	10.0
Cylinder Walls	8.5	9.0	8.5	9.5
Crankcase Oil Pan	9.5	9.5	10.0	10.0
Varnish Total	44.8	45.2	44.9	48.9
Sludge Deposits				
Rocker-Arm Assembly	9.8	9.8	9.5	9.8
Rocker-Arm Cover Plate	10.0	10.0	10.0	9.8
Push-Rod Cover Plate	9.8	9.8	10.0	9.8
Oil Screen	10.0	10.0	10.0	10.0
Crankcase Oil Pan	9.8	9.5	10.0	9.5
Sludge Total	49.4	49.1	49.5	48.9
Combined Engine Deposit Rating for Varnish and Sludge	94.2	94.3	94.4	97.8
Copper-Lead Bearings				
Bearing A, grams loss	0.094	0.042	0.004	0.008
Bearing B, grams loss	0.079	0.068	0.007	0.010

REFERENCES

[1] Acryloid HF-845, HF-855, HF-865 and HF-8125 manufactured by Rohm and Haas Company, Philadelphia.

[2] Paratone sold by Stanco Distributors Incorporated.

[3] E. W. Hardiman and A. H. Nissan, Jour. Petr. Inst., 31 255-70 (1945) where v_1 = centistokes at 100° F. and v_2 = centistokes at 210° F.

$$n = \frac{\log v_1 - 0.4336}{\log v_2}; \quad \text{V.I.} = (60.0 = \text{antilog } n)\ 3.63$$

[4] Prestone Motor Oil manufactured by Carbide and Carbon, Inc.

[5] Acryloid 150 manufactured by Rohm and Haas Company.

[6] Acryloid 710 manufactured by Rohm and Haas Company.

TABLE 7
Oil Analysis Data on Engine Tests on 140 V.I. ACRYLOID-Oil Blend

Blend consists of 2.0 weight percent ACRYLOID added to a Barosa SAE-10 blend containing 0.75 weight percent Santolube 394C
Samples filtered and stripped for viscosity determination

TEST	Miles	Hours	210° F. Cs.	210° F. S.U.S.	100° F. Cs.	100° F. S.U.S.	V-I	Percent Naphtha Insoluble	Percent Chloroform Soluble	Neut. No.	ASTM Pour Point °F.
Special 40-Hour Chevrolet Engine Test	....	0	10.60	61.33	63.35	293.8	140.8	....	....	....	—35
	....	8	9.86	58.7	59.61	275.6	139.0	0.7	0.22	0.54	—35
	....	12	9.70	58.2	58.79	271.8	138.5	0.73	0.21	0.82	—35
	....	24	9.49	57.5	57.75	267.0	137.5	0.93	0.21	1.24	—35
	....	32	8.91	55.5	54.03	250.0	136.8	1.01	0.27	1.36	—35
	....	40	9.06	56.0	56.61	261.9	134.4	0.99	0.24	1.76	—35
1941 Mercury 848 miles per Quart	500	....	10.05	59.4	60.25	278.5	139.9	0.06	0.04	0.14	—35
	1002	....	10.19	59.9	63.67	294.3	136.9	0.04	0.04	0.54	—35
	1510	....	9.54	57.6	59.81	276.6	135.2	0.06	0.04	0.30	—35
	2000	....	9.81	58.6	60.76	280.9	136.8	0.07	0.05	0.42	—35
	2500	....	9.51	57.5	60.07	277.8	134.3	0.06	0.03	0.36	—35
1941 Pontiac 750 miles per Quart	427	....	9.71	58.2	58.73	271.6	138.5	0.30	0.08	0.59	—35
	800	....	9.33	56.9	57.58	266.3	136.2	0.30	0.18	1.52	—35
	2242	....	9.37	57.1	59.52	275.2	133.7	0.28	0.05	2.54	—35
1940 Chrysler 900 miles per Quart	479	....	9.98	58.80	61.75	285.4	137.2	0.02	0.01	0.19	—35
	1026	....	10.13	59.6	64.75	299.3	134.8	0.07	0.04	0.24	—35
	2057	....	9.76	58.4	61.83	285.8	134.9	0.02	0.01	0.34	—35
1939 Plymouth 320 miles per Quart	566	....	10.24	60.1	63.32	292.7	137.8	0.06	0.02	0.19	—35
	1053	....	9.37	57.1	56.10	259.5	138.9	0.07	0.05	0.14	—35
	1489	....	9.67	58.1	58.77	271.7	138.2	0.10	0.07	0.24	—35
	2023	....	9.92	58.9	61.59	284.7	136.9	0.04	0.03	0.33	—35
	2645	....	10.09	59.5	62.76	291.1	137.0	0.06	0.04	0.33	—35
	3224	....	9.57	57.7	59.96	277.2	135.3	0.04	0.03	0.33	—35
	3685	....	9.96	59.1	61.72	285.3	137.1	0.04	0.04	0.33	—35

Simplified Multi-Component Fractionation Calculations

Part III

MULTI-COMPONENT TRAY CALCULATIONS

RAYMOND V. BAILEY and JESSE COATES

OFTEN it is desirable, in order to make a heat balance around the feed tray, to know the feed tray composition and temperature as well as the tray requirements for a given reflux ratio. In many of these cases the true minimum reflux is not of primary significance. Therefore, it is desirable to have a rapid method of estimating the tray requirements without recourse to the calculaions necessitated in Parts I and II. (REFINER, January and February, 1948.)

Hengstebeck[8] placed multicomponent systems on a two-component basis by defining an equivalent ratio of liquid to vapor in each section of the column based on the pinch compositions. The definition of the equilibrium curve is correct only at total reflux, and the definition of the equivalent operating lines does not permit application of the method at reflux ratios approaching the minimum. In addition, heavy components or light components which might persist practically the entire length of the fractionating or stripping section, respectively, are not considered in the definition of the pseudo operating lines. Thus, in general, the method is applicable only to easily separated components at large reflux ratios.

Jenny's[11] method would suffice for the tray determinations, but the method offered here eliminates the trial and error in obtaining the feed tray temperature and the several multicomponent tray calculations required in order to establish the equilibrium curve for the Jenny[11] method.

In obtaining the feed tray composition and temperature, the feed tray action must be considered.

Gilliland[5] gives equations for the optimum feed tray for the following cases:

Case 1. Vapor entering the plate above the feed tray has the same composition as the vapor leaving the feed tray.

$$\left(\frac{X_{1K}}{X_{hK}}\right)_f \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_1 \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_{f+1}$$

Case 2. Feed is part vapor. Vapor portion mixes physically with the vapor rising from the feed tray, but does not react with the feed tray liquid.

$$\left(\frac{X_{1K}}{X_{hK}}\right)_f \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_F \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_{f+1}$$

Case 3. Feed is all vapor and mixes with the feed tray vapor, but does not react with the liquid on the feed tray.

$$\left(\frac{X_{1K}}{X_{hK}}\right)_{f+1} \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_1 \gtrless \left(\frac{X_{1K}}{X_{hK}}\right)_{f+2}$$

where

X_{1K} = Mole fraction of light key in liquid
X_{hK} = Mole fraction of heavy key in liquid

Subscripts:

f = feed tray
$f+1$ = tray above feed
$f+2$ = second tray above feed
1 = intersection of operating lines of key components
F = feed

Since, as pointed out by Gilliland,[5] the optimum feed tray is a function of the feed tray action, multicomponent calculations will be placed on a two-component basis for both types of feed tray action.

In general, the feed tray action will have no appreciable effect on the total number of trays, but the optimum feed tray and feed tray temperature may be considerably affected.

Case I: The Feed Vapor Is Considered in Equilibrium with the Feed Tray Liquid

If the equivalent composition based on the key

THIS is the third and final part of a series which has appeared in consecutive issues of *Petroleum Refiner* presenting calculation procedures applicable to multi-component fractionation. In Part I a modification of the Scheibel-Montross[17] equation for minimum reflux was treated. In Part II a psuedo reflux ratio and an equilibrium curve was defined for the application of the Scheibel[15] method of tray determinations. This Part III contains a graphical solution for tray requirements which is more advantageous than the modified Scheibel method of Part II if a heat balance around the feed point is necessary and the minimum reflux ratio is not of primary significance. In addition, the proposed method permits a check on the assumed distribution of a split key.

The graphical solution presented is somewhat similar to the method proposed by Hengstebeck[8], but with the pseudo operating lines and equilibrium curve defined in such a manner as to permit application of the method at reflux ratios near the minimum as well as reflux ratios which are large compared to the minimum.

Multi-component systems are placed on the basis of the key components by the definitions:

$$x = \frac{X_{1K}}{\Sigma X_{K's}}$$

$$y = \frac{Y_{1K}}{\Sigma Y_{K's}}$$

The equilibrium curve and pseudo operating lines are determined by a calculation of the composition on the feed tray and the tray above the feed.

The proposed method requires fewer calculations than the method of Jenny[10] and eliminates the trial and error in the determination of the feed tray temperature.

The maximum error is about 5 percent.

Nomenclature appears on last page of article.

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components is defined as

$$x = \frac{X_{lK}}{X_{lK} + X_{hK}}$$

$$y = \frac{Y_{lK}}{Y_{lK} + Y_{hK}}$$

where

x = mole fraction of the light key in the liquid on a two-component basis
y = mole fraction of the light key in the vapor on a two-component basis
X = mole fraction in the liquid on a multicomponent basis
Y = mole fraction in vapor on a multicomponent basis

Subscripts:
$_{hK}$ = heavy key component
$_{lK}$ = light key component

then the points x_w and x_D
where subscript w = Bottoms
$_D$ = Overhead
are readily plotted on a McCabe-Thiele diagram.

The feed tray composition may then be calculated by noting that usually in the fractionating section a few trays below the condenser the *vapor* composition of the components lighter than the light key has been reduced to a constant value even though the liquid composition may be changing quite rapidly. Similarly, in the stripping section, a few trays from the reboiler the *liquid* composition of the components heavier than the heavy key has attained a constant value even though the vapor composition may be changing quite rapidly. At the pinches, the vapor and liquid composition becomes constant in each section.

From the equations of the operating lines and the above observations it follows that for components lighter than the light key

$$X_f = \frac{d}{V_n\left(K_f - \frac{L_n K_f}{V_n K_{f+1}}\right)} \qquad (21)$$

Note 1. If L_n/V_n is small compared to K_f then the ratio K_f/K_{f+1} may be assumed to be one without introducing appreciable error.

Similarly for the components heavier than the heavy key

$$X_f = \frac{w}{V_m\left(\frac{L_m}{V_m} - K_f\right)} \qquad (22)$$

Where

X = mole fraction in liquid
d = moles of component in overhead
V = moles of vapor up-flow
L = moles of liquid down-flow
w = moles of component in bottoms
K = equilibrium constant

Subscripts:
$_n$ = fractionating section
$_m$ = stripping section

A feed tray temperature is assumed by using the pinch temperatures, as set forth by Jenny,[11] as a guide. This assumed temperature need not be the optimum in order to establish accurately the operating lines and obtain the optimum feed tray. The liquid compositions on the feed tray for the light and heavy components are calculated by equations (21) and (22). The vapor compositions are calculated by

$$Y_f = K_f X_f$$

and the compositions of the keys obtained by simultation.

Calculations are then made to obtain

1) liquid composition of tray f + 1;
2) boiling point of liquid on tray f + 1;
3) vapor composition of keys on tray f — 1.

Then, by placing trays f, f + 1, and f — 1 on a two-component basis in the same manner as the bottoms and overhead, x_f, y_f, x_{f+1} and y_{f-1} are obtained and the pseudo operating lines can be drawn, since two points have been established on each operating line:

1) x_D and (y_f, x_{f+1}) for fractionating section.
2) x_w and (x_f, y_{f-1}) for stripping section.

From a boiling point calculation of the bottoms and a dew point of the overhead, the relative volatility of the keys is known at four points (bottom, tray f, tray f +1, and top) over the temperature range of the multicomponent system. The liquid composition on a two-component basis is also known at these four points. A smooth curve of relative volatility versus liquid composition (on a two-component basis) through the points (x_t, α_t), (x_{t+1}, α_{t+1}) and (x_w, α_w) will, for all practical engineering purposes, sufficiently define the equilibrium curve for the fractionating section. Similarly, a curve through the points (x_w, α_w), (x_f, α_f), and (x_t, α_t) will sufficiently define the equilibrium curve for the stripping section.

If the variation of the relative volatility with temperature is small near the feed tray temperature the boiling point calculation for tray f + 1 is unnecessary and only the liquid composition of the keys for tray f + 1 need be calculated.

The equilibrium curve is obtained from the relation

$$y = \frac{\alpha x}{1 + (\alpha - 1)x}$$

where α = relative volatility of the light key with reference to the heavy key.

The trays are then stepped off as on the conventional McCabe-Thiele diagram for a two-component system.

If the variation of the relative volatility is very small over the entire temperature range of the multicomponent system there is no necessity for the calculation of the boiling point of the bottoms and the dew point of the overhead and the determination of the number of trays becomes extremely simple.

Determination of Optimum Feed Tray for Case I:

The optimum feed tray is that tray which straddles the intersection of the pseudo operating lines.

Determination of Optimum Feed Tray Temperature for Case I:

For assumptions of feed tray temperatures over a range of several degrees the ratio of $\Sigma Y/\Sigma X$ for the keys does not change appreciably. The equilibrium constant for the light key is equal to $y\Sigma Y/x\Sigma X$. The ratio y/x is obtained from the equilibrium curve for the two-component system at the optimum feed tray. $\Sigma Y/\Sigma X$ for the keys is obtained from the feed tray composition calculation.

If the assumed feed tray temperature varies considerably from the calculated optimum, a second calculation of the feed tray composition may be made if a very accurate optimum feed tray temperature is desired. However, this large difference in tempera-

tures (assumed and optimum) will, in general, have no appreciable effect on the tray determinations.

Minimum Reflux:

For reflux ratios near the minimum, the keys may pass through a maximum concentration value as shown by rearrangement of the equations of the operating lines illustrated by Jenny.[11] If the pinch temperatures show that the keys pass through a maximum before reaching the feed tray for the stripping section, and the tray above the feed for the fractionating section, tray calculations must be made through these maximum values in order to establish the pseudo operating lines on the two component diagram.

Case II. The Vapor of the Feed Is Not in Equilibrium With the Feed Tray Liquid

The placing of the multicomponent system on a two-component basis is essentially the same as for Case I, but with the following adjustments:

1) Calculation of feed tray composition;

A temperature spread is assumed between the feed tray and the tray above, with the spread being equally distributed on either side of the pinch temperatures as illustrated by Jenny,[11] thus obtaining the first assumption of temperatures of the feed tray and the tray above.

As before, rearranging the operating lines and noting the *vapor* composition of the light components in the fractionating section and the *liquid* composition of the heavy components in the stripping section approach a constant value then for the light components.

$$v_{f+F} = \frac{d}{1 - \frac{L_n}{V_n K_{f+1}}} \qquad (23)$$

and for the heavy components

$$l_f = \frac{w}{1 - \frac{V_m K_f}{L_m}} \qquad (24)$$

where

v_{f+F} = mols of vapor from feed tray plus mols of vapor from feed for a light component

l_f = mols of heavy component in liquid on feed tray.

The composition of the light and heavy components on trays f and f+1 may be calculated from equations (23) and (24) and a material balance around the feed point. The composition of the keys is obtained by simultation.

2) Determination of operating lines

The point (y_f, x_{f+1}) no longer locates a point on the operating line for the fractionating section because this is not an equilibrium step directly from the feed tray. Therefore, calculations of the composition of the keys must be carried to tray f+2 such that (y_{f+1}, x_{f+2}) locates the pseudo operating line for the fractionating section.

As an alternate, the lowest point on the operating line for the fractionating section may be taken as (y'_f, x_{f+1})

Where y'_f = mole fraction of the light key component, on a two component basis, in the Vapor phase above the feed point and entering the tray above the feed.

Determination of Optimum Feed Tray for Case II:

The optimum feed tray will lie between that for an all liquid feed (feed tray straddles intersection of operating lines) and an all vapor feed (tray f+1 straddles intersection of operating lines).

Determination of Optimum Feed Tray Temperature for Case II:

The optimum feed tray temperature is calculated as for Case I.

EXAMPLE III

Case I. Assume vapor of feed in equilibrium with feed tray liquid.

Debutanizer reference.[16]

	Mols Feed	Mols Overhead	Mols Bottoms
C_3	1.0	1.0	....
C_4	40.0	39.4	0.6
C_5	23.0	0.4	22.6
C_6	16.0	....	16.0
C_7	12.0	....	12.0
C_8	8.0	....	8.0
	100.0	40.8	59.2

Equilibrium Flash on Feed: 220° F. 100 psia.

	$K\left(\frac{100\ psia.}{220°\ F.}\right)$	Mols Vapor	Mols Liquid
C_3	4.5	0.6	0.4
C_4	1.96	15.8	24.2
C_5	.93	5.4	17.6
C_6	.45	2.1	13.9
C_7	.21	0.8	11.2
C_8	.105	0.3	7.7
		25.0	75.0

Tower operates at 100 psia.

Dewpoint of Overhead

	Mols Vapor	$K_{145°}$	V/K
C_3	1.0	2.6	0.4
C_4	39.4	1.00	39.4
C_5	0.4	0.38	1.0
	40.8	....	40.8

Boiling point of bottoms

	Mols	$K_{278°}$	MK
C_4	0.6	3.1	1.9
C_5	22.6	1.60	36.2
C_6	16.0	0.86	13.8
C_7	12.0	0.45	5.4
C_8	8.0	0.25	2.0
	59.2	....	59.3

Reflux Ratio=3 mols reflux per mole overhead

$L_n = 122.4$ $\left(\frac{L}{V}\right)_n = 0.75$

$V_n = 163.2$ Temp. = 199° F. when $K_{c_5} = 0.75$

$L_m = 197.4$ Approximate fractionating pinch temperature

$V_m = 138.2$ $\left(\frac{V}{L}\right)_n = 1.333$

$\left(\frac{L}{V}\right)_m = 1.428$ Temperature = 182° F. when $K_{c_4} = 1.428$

Approximate stripping pinch temperature.

Calculation of feed tray composition:

The feed tray temperature is, in general, larger than the stripping pinch temperature, modified of course, by the quantity of light components present. Since the quantity of light components for this case must be small, a feed tray temperature of 200° F. was assumed.

	K_{200}	$\left(\frac{L}{V}\right)_m^{-K_f}$	$X_f = \frac{w}{V_m\left[\left(\frac{L}{V}\right)_m^{-K_f}\right]}$	$K_f - \left(\frac{L}{V}\right)_n$	$X_f = \frac{d}{V_n\left[K_f - \left(\frac{L}{V}\right)_n\right]}$
C_3	3.98			3.23	.00189
C_4	1.689				
C_5	0.76				
C_6	0.355	1.073	0.1076		
C_7	0.159	1.269	0.0685		
C_8	0.078	1.350	0.0428		

STRIPPING SECTION			FRACTIONATING SECTION		
α	x	y	α	x	y
1.95	.05	.0934	2.30	0.50	.697
1.98	.10	.1805	2.38	0.60	.782
2.04	.20	.339	2.44	0.70	.850
2.10	.30	.474	2.51	0.80	.910
2.17	.40	.591	2.58	0.90	.959
2.23	.50	.690	2.61	0.95	.980
2.31	.60	.775			

	X_f	$Y_f = K_f X_f$
C_3	.00189	.00754
C_5	.1076	.0382
C_7	.0685	.0109
C_8	.0428	.00334
	.2208	.05998

$$X_4 + X_5 = 1 - .2208$$
$$1.689\,X_4 + 0.76\,X_5 = 1 - .05998$$

By simultation

$X_4 = 0.376 \quad Y_4 = 0.634$

$X_5 = 0.403 \quad Y_5 = 0.306$

Summarizing for feed tray:

	X_f	Y_f
C_3	.00189	.00754
C_4	.376	.634
C_5	.403	.306
C_6	.1076	.0382
C_7	.0695	.0109
C_8	.0428	.00334

Calculation of composition on tray f + 1: $\left(\frac{V}{L}\right)_n = 1.333$

	1.333 Y_f	$-0.333X_D$	$= X_{f+1}$	K.80	KX_{f+1}	$KX_{Adj.}$
C_3	.0101	.0081	.0020	3.42	.0069	
C_4	.844	.322	.522	1.41	.7350	.735
C_5	.4075	.003	.404	.60	.2420	.242
C_6	.0510	.000	.0510	.27	.0138	
C_7	.0145	.000	.0145	.12	.0017	
C_8	.0044	.000	.0044	.055	.0002	
					.9996	

Calculation of keys on tray f − 1: $\left(\frac{L}{V}\right)_m = 1.428$

	$1.428X_f$	$- 0.428X_w$	$= Y_{f-1}$
C_4	.535	.0043	.531
C_5	.574	.163	.411
			.942

On a two-component basis:

$$\alpha = \frac{K_{c3}}{K_{c4}}$$

	α
$x_D = .99$	
$x_w = .0258$	1.94
$x_f = 0.976$	2.63
$x_f = 0.483$	2.22
$x_{f+1} = 0.563$	2.35

$y_{f-1} = .5645$

$z_F = 0.635$

Figure 3 represents the plot of α vs x

From Figure 3 and $y = \frac{\alpha x}{1 + (\alpha - 1)x}$

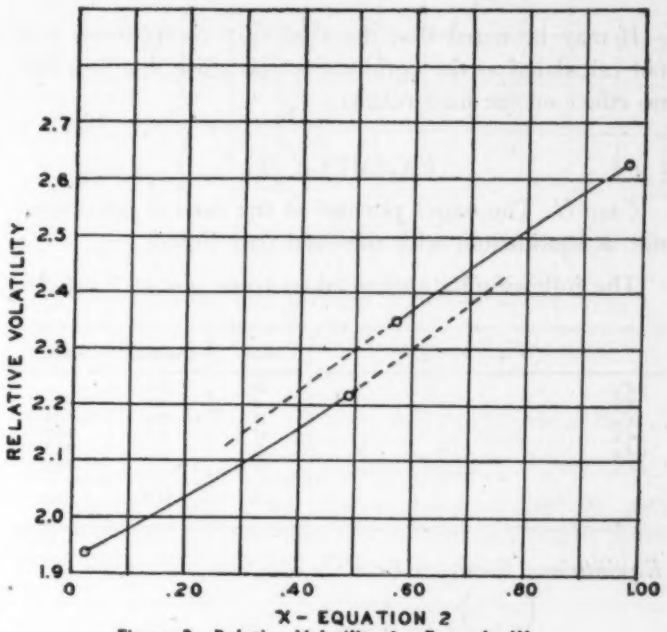

Figure 3—Relative Volatility for Example III.

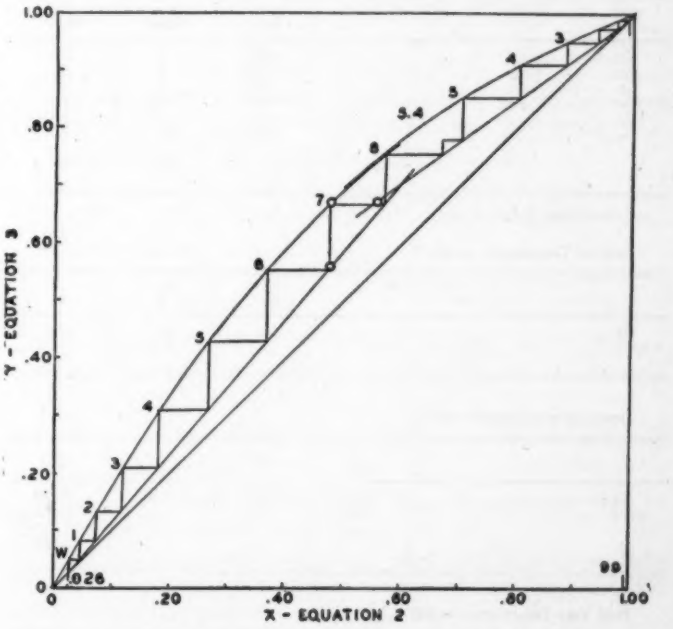

Figure 4—Determination of Trays for Example III.

The equilibrium curves are drawn on Figure 4 and the operating lines plotted from x_D and (x_{f+1}, y_f) and x_w and (y_{f-1}, x_f).

The trays are stepped off as on the conventional McCabe-Thiele[1] diagram.

Optimum Feed Tray:

Step that passes over intersection of the operating lines = 8th tray above reboiler.

Optimum Feed Tray Temperature:

From calculation of feed tray composition

$\Sigma X_{keys} = 0.779$
$\Sigma Y_{keys} = 0.940$

From Figure 4:

$y_f = 0.75$
$x_f = 0.57$

$$K_{c4} = \frac{(0.75)\,(0.940)}{(0.57)\,(0.779)} = 1.59 \text{ at optimum feed tray}$$

Temperature = 195° F.
From tray calculation = 195° F.

It may be noted that the feed tray composition was not calculated at the optimum temperature, but this had no effect on the final results.

EXAMPLE IV

Case II. The vapor portion of the feed is considered not in equilibrium with the feed tray liquid.

The following data were taken from Jenny's[11] article:

	Feed	Overhead	Bottoms
C_1	26	26.0	....
C_2	9	9.0	....
C_3	25	24.6	0.4
n-C_4	17	0.3	16.7
n-C_5	11	....	11.0
n-C_6	12	....	12.0
	100	59.9	40.1

Equilibrium Flash on Feed:

$$\left(\frac{V}{L}\right)_F = 2$$

	K_{175}	Liquid	Vapor
C_1	13.0	1	25
C_2	3.2	1	8
C_3	1.3	7	18
C_4	0.63	8	9
C_5	0.27	7	4
C_6	0.13	10	2
	....	34	66

Reflux Ratio = 1.5

Reboiler Temperature = 300° F.

	K	α
C_3	2.7	1.86
n-C_4	1.45	

Dewpoint of Overhead = 63° F.

	Y_D	K	α	X_t
C_3	.411	0.51	3.18	0.810
n-C_4	.005	0.16	....	0.032
	....	....	....	0.842

Feed Tray Temperature = 205° F.

	X_f	K	α	Y_f
C_3	.351	1.55	1.938	0.544
n-C_4	.404	0.80	....	0.323
	....	....	....	0.867

Tray f+1: Temperature = 160° F.

	1	K	α
C_3	39.0	1.14	2.11
C_4	35.8	.54	....
	74.8	....	....

	Tray f—1		Tray f+2
	Y_{f-1}		X_{f+2}
C_3	0.512	C_3	0.556
C_4	0.397	n-C_4	0.357
	0.909		0.913

On a Two-Component Basis:

	α
$x_D = 0.988$	....
$x_w = .0234$	1.86
$x_1 = 0.96$	3.18
$x_f = 0.465$	1.938
$x_{f+1} = 0.521$	2.11
$x_{f+2} = 0.610$	....
$y_{f-2} = 0.564$	....
$x_F = 0.595$	....

Figure 5 is a plot of α vs. x. A smooth curve is drawn through (α_w, x_w), (α_f, x_f), and (α_t, x_t) for the stripping section equilibrium curve and through (α_w, x_w), (α_{f+1}, x_{f+1}), and (α_t, x_t) for the fractionating section equilibrium curve.

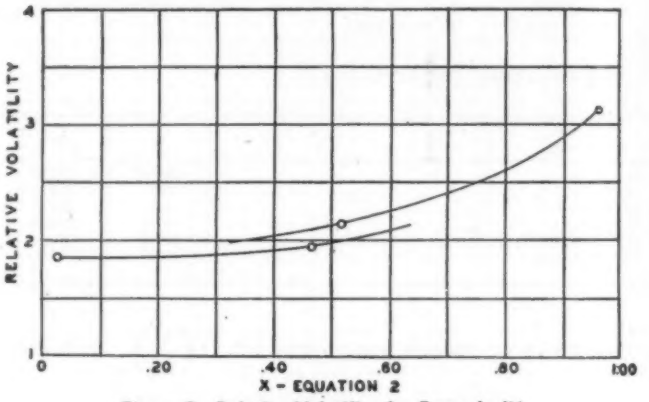

Figure 5—Relative Volatility for Example IV.

From Figure 5:

FOR STRIPPING SECTION			FRACTIONATING SECTION		
α	x	y	α	x	y
1.87	0.1	0.174	2.1	0.5	0.677
1.90	0.2	0.322	2.25	0.6	0.771
1.91	0.3	0.450	2.40	0.7	0.849
1.92	0.4	0.561	2.64	0 8	0.914
1.98	0.5	0.665	2.95	0 9	0.965
2.1	0.6	0.775	3.13	0 95	0.985

The graphical solution for the tray requirements is shown in Figure 6.

Optimum Feed Tray:

Since the feed was over 50 percent vaporized, the concentration of x_{f+1}, fell slightly below the intersection of the operating lines (discussed previously), and the point (y_f, x_{f+1}) fell between the two operating lines due to the type of feed tray action assumed.

Feed Tray Temperature:

The feed tray temperature is 205° F. since x_f on the graph corresponds to the value determined from the feed tray composition calculated using 205° F. as the assumed temperature.

EXAMPLE V

Determination of feed tray composition for the case of a split key.

The vapor of the feed is considered in equilibrium with the feed tray liquid.

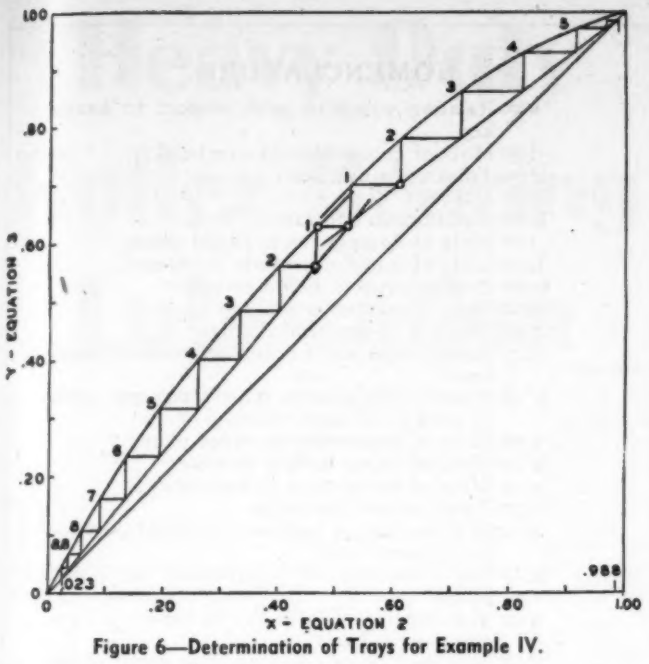

Figure 6—Determination of Trays for Example IV.

Depropanizer example of Jenny's[11] with split key.

Material Balance:

	Feed	Overhead	Bottoms
C_1	3	3.0	....
C_2	7	7.0	....
C_3	15	14.7	0.3
n-C_4	33	8.2	24.8
n-C_5	30	0.03	30.0
n-C_6	12	....	12.0
	....	32.9	67.1

Reflux Ratio = 1.75

$\frac{L_n}{V_n} = 0.635$ $\qquad \frac{V_n}{L_n} = 1.575$

$\frac{L_m}{V_m} = 2.13$ $\qquad V_n = 90.4$

$V_m = 59.4$

Tower pressure = 200 psia.

From Jenny's[11] calculations.

Reboiler Temperature = 265° F.

	MPH	K_{265}	MK
C_3	0.3	3.15	1.0
n-C_4	24.8	1.52	37.6
n-C_5	30.0	0.80	24.0
n-C_6	12.0	0.45	5.4
	67.1	....	68.0

Overhead: Temperature = 120° F.

	MPH	K_{120}	M/K	X_t
C_3	14.7	1.13	13.0	.388
n-C_4	8.2	0.46	17.8	.531
n-C_5	0.03	0.16	0.2	.006

Now if a heavy key is selected

$$hK = C_4 + C_5$$

in order to calculate the feed tray composition, a plot of K_{hK} vs. K_{C_4} will be a straight line as shown in Figure 7.

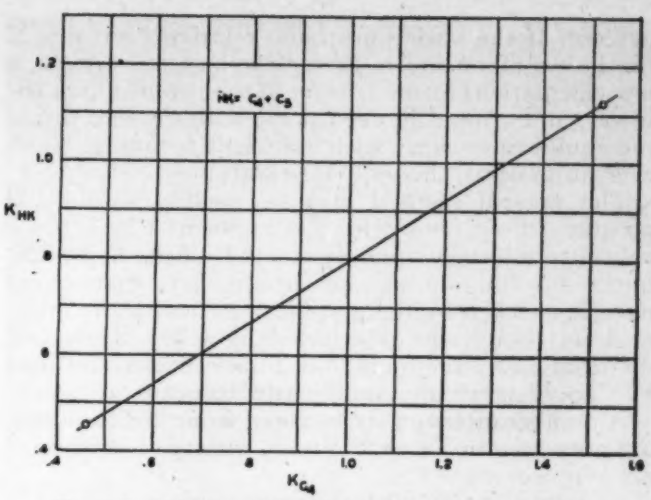

Figure 7—Definition of Equilibrium Constant—Example V.

The points for the plot are obtained as follows:

Top: $K_{C_4} = 0.46$ $\qquad K_{hK} = \frac{8.23}{18.0} = 0.456$

Bottom: $K_{C_4} = 1.52$ $\qquad K_{hK} = \frac{61.6}{54.8} = 1.125$

Calculation of Feed Tray Composition:

Assume Feed Tray temperatures = 200° F. and calculate the composition of the light and heavy components as in Example III.

	K_{200}	X_f	Y_f
C_1	22	.00156	.0343
C_2	5.3	.01661	.0880
C_3	2.08	*.1291	*.269
n-C_4	.98	*.476	*.466
n-C_5	.44	*.2707	*.1191
n-C_6	.22	.1060	.0233

* Calculation of concentration of C_3, n-C_4 and n-C_5.

From Figure 7: $K_{hK} = 0.785$ when $K_{C_4} = .98$

$X_3 + X_{hK} = 1 - (.00156 + .01661 + .1060) = .8758$

$2.08X_3 + 0.785X_{hK} = 1 - (.0343 + .0880 + .0233) = .8544$

By simultation:

$X_3 = .1291$ $\qquad Y_3 = .269$

$X_{hK} = .7467$ $\qquad Y_{hK} = .5854$

$X_4 + X_5 = .7467$

$.98X_4 + .44X_5 = .5854$

By simultation:

$X_5 = .2707$ $\qquad Y_5 = .1191$

$X_4 = .476$ $\qquad Y_4 = .466$

The tray requirements are then determined as in Examples IV and V.

The initial distribution of the intermediate key may be checked by using it as one of the keys on the same type diagram.

Discussion and Conclusions

The method presented offers a solution to the number of trays at any reflux ratio, optimum feed tray and optimum feed tray temperature with fewer calculations than are required by other methods of equal accuracy.

The greatest inaccuracy in the method lies in the determination of the equilibrium curve. However, even with very large variations of the relative volatility of the key components, the equilibrium curve is defined with sufficient accuracy to give the tray requirements with a maximum error of about five

percent. If the variation of the relative volatility of the key components is extremely large or erratic, a few calculations at the bottom of the tower, top of the tower, and around he feed point will serve to define the equilibrium curve with sufficient accuracy. However, in general, this is unnecessary.

The present method may be applied with equal accuracy to systems with a component which has a volatility intermediate between that of the keys. The initial distribution of the intermediate component may be checked by the graphical method if the intermediate component is selected as a key. However, distribution by the method of total reflux as outlined by Carey[18] is usually sufficiently accurate.

A number of examples, selected from the literature, are presented in Table 3. A wide variety of conditions are represented:

1) Up to 70 percent light components.
2) Up to 70 percent heavy components.
3) As many as 13 components.
4) Split keys.
5) Conditions of feed from all liquid to all vapor.
6) Relative volatility of the keys from 1.26 to 7.
7) Two-fold variation of the relative volatility of the key components from reboiler to overhead.

Case 8 in Table 3, which involved a split key with a large quantity of the intermediate component, small amounts of the key components, large variation of the relative volatility of the key components, and 13 components, demonstrates the broad application of the method.

The method is especially advantageous for those cases in which the feed tray concentration and temperature are necessary for a heat balance around the feed point.

For many systems the equilibrium curve does not change appreciably with a moderate change in reflux ratio. Thus, in design work, one equilibrium curve may suffice for several reflux ratios—the pseudo reflux ratio being determined by noting that over a limited range the ratio of the pseudo reflux ratio to the actual reflux ratio is constant.

TABLE 3
Comparison of Tray Calculations for Part III

PROBLEM	Reference	Method	Strip.	Trays Fract.	Total
1. Debutaniser	(16)	Author	8	5.4	13.4
		Calc.	8	5.6	13.6
2. Case B	(15)	Author	10.2	8.8	19.0
		Calc.	10.7	8.8	19.5
3. Case C	(15)	Author	9.5	10.2	19.7
		Calc.	9.3	10.1	19.4
4. Case E	(15)	Author	6.6	10.3	16.9
		Calc.	6.8	9.9	16.7
5. Case F	(15)	Author	7.2	9.2	16.4
		Calc.	7.2	9.2	16.4
6. Case G	(15)	Author	7.8	7.2	15.0
		Calc.	7.3	7.0	14.3
7. Phenol, O-cresol, etc	(14)	Author	13.5	13.0	26.5
		Calc.	13	13	26.0
8. Depropaniser, Stabiliser	(13)	Author	7.1	6.0	13.1
		Calc.	7 to 8	5 to 6	12 to 14
9. Depropaniser	(11)	Author	8.8	5.8	14.6
		Jenny	8.8	5.7	14.5
10. Depropaniser Split Key	(11)	Author	10.0	6.1	16.1
		Jenny	10.2	5.5	15.7

NOMENCLATURE

- α = Relative volatility with respect to heavy key
- d = Mols of component in overhead
- D = Total mols overhead
- f = Function
- K = Equilibrium constant = Y/X
- l = Mols of component in liquid phase
- L = Mols of liquid downflow in column
- m = Pseudo ratio of liquid to vapor
- M = Mols of component
- N = Number of theoretical trays
- R = Reflux ratio, mols reflux per mole of overhead
- R′ = Pseudo reflux ratio, mols reflux per mole of keys overhead
- v = Mols of component in vapor phase
- V = Mols of vapor upflow in tower
- w = Mols of component in bottoms
- W = Total mols of bottoms
- x = Mol fraction of light key in liquid on two-component basis.
- X = Mol Fraction of component in liquid phase
- y = Mol fraction of light key in vapor on two-component basis.
- Y = Mol fraction of component in vapor phase
- z = Mol fraction of light key in vapor plus liquid on two-component basis
- Z = Total mol fraction of component (liquid + vapor)

Subscripts:

- D = Overhead
- f = Feed tray
- F = feed
- h = heavy component, heavier than heavy key
- hK = heavy key
- i = intersection of operating lines
- l = light component, lighter than light key
- lK = light key
- L = liquid
- m = stripping section
- M = minimum
- n = fractionating section
- t = top tray
- v = vapor
- w = bottoms

Superscripts:

- ′ = pseudo

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Heavy Duty Roller Bearing Lubrication

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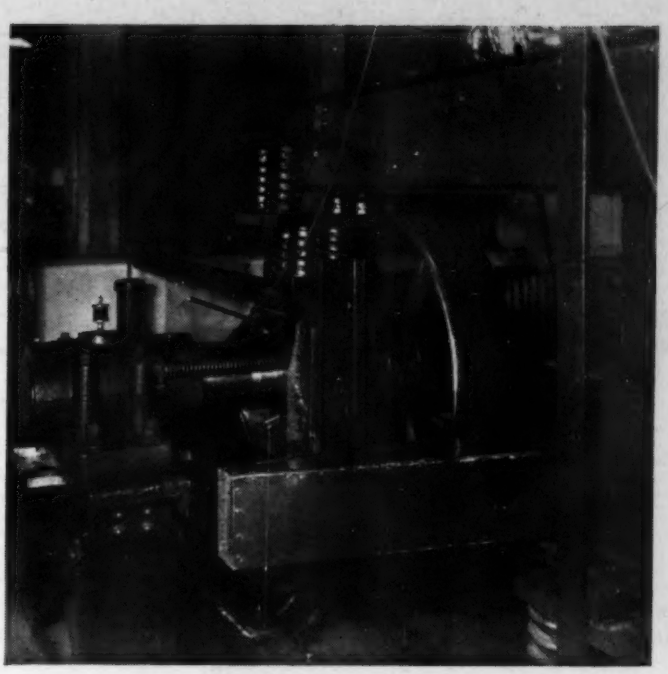


Figure 1—Testing machine for ball or roller bearing greases. (Courtesy Sinclair Refining Company, New York.)

HEAVY duty roller bearings have assumed a position of major importance in industry and are extensively used by the railroads. For satisfactory service from these bearings adequate lubrication is an absolute necessity. In his article the author discusses pertinent factors in the utilization and lubrication of several of the more usual types of such bearings. The material presented reflects many years experience in industrial lubrication and should prove interesting to all who must deal with similar problems. Since the great bulk of industrial lubricants are petroleum oils and greases containing petroleum as a major constituent, it is somewhat surprising that many refinery chemists and engineers are relatively uninformed along these lines.

***Petroleum Refiner* plans to present further articles dealing with lubricants and greases as there is currently a widespread development in this field.**

THE tremendous industrial loads carried by the ever-increasing use of both ball and roller bearings, require metallurgical precision manufactured bearings.

The frictional resistance in a bearing is dependent upon several factors, such as, type and condition of the surfaces, the areas of the surfaces, the pressure and velocity of rubbing, etc. The ratio of frictional resistance to the load is called the coefficient of friction.

To obtain the best results in lubrication at the present day high speeds in actual service, these bearings need highly refined compounded oils and greases which will produce the lowest coefficient of friction. Since the most important factor in the operation of a bearing is its lubrication, the oil or grease that shows the lowest coefficient of friction and also meets all the specifications for the required product, is not only the best lubricant, but most economical.

Centuries ago, the Egyptians found that a body rolling over a surface required less effort to move, than pulling it on a sledge and thus discovered that rolling friction is much less than sliding friction.

Anti-Friction Bearings

In ball or roller bearings, "friction" can be overcome by changing sliding friction to roller friction and such bearings are designated as anti-friction bearings. They are manufactured in various sizes and shapes, such as tapered rollers, ball, straight rollers, barrel rollers, concave rollers and needle roller bearings. They are obtainable in single and double rows, suitable for automotive, aeronautical and for many industrial installations. Bearings can be had with or without self-aligning features.

When properly lubricated and protected against dirt, water, etc., they will show no appreciable wear even after long periods of service. They can be easily replaced as complete units. With the present highly developed bearing greases, pre-packed bearings can be operated under normal conditions for a long time without requiring re-lubrication; however, some of these bearings on special equipment are now furnished with plugs, which will allow the operator or greaser to add additional grease without disassembling the unit.

In plain bearings, friction between the rubbing surface, that is, sliding friction such as occurs in an ordinary sleeve type bearing is reduced to a minimum by proper clearance in the bearings, correct grooving, suitable amount and uniform feed of the right lubricant to the bearing, ideal load and speed for the particular lubricants selected. The lubricant—either oil or grease—must be compounded in such a way and with such raw materials that will result in keeping the coefficient of friction the lowest possible. Low coefficient of friction in a lubricant is due to a number of factors, such as, oiliness, proper cohesion and adhesion, affinity of the lubricant to the metals, film strength, etc. A very small percentage of fatty acids in oils will sometime increase the oiliness and adhesion, especially useful when bearings operate in the region of partial lubrication; however, under conditions of fluid friction, the oiliness factor in an oil is of no value.

These phenomena can be checked by chemical and physical tests. Figure 1 shows a laboratory testing machine used in evaluating ball or roller bearing greases.

Figure 2 shows the results obtained in a 22½-hour test run with two roller bearing greases. Speed was at the rate of 80 miles per hour, and the test represented 1811¼ miles. Only two stops of 8 hours were made, these after the first and second runs.

The bearings used were a spherical ground, two-row roller type, the pressure per square inch on the

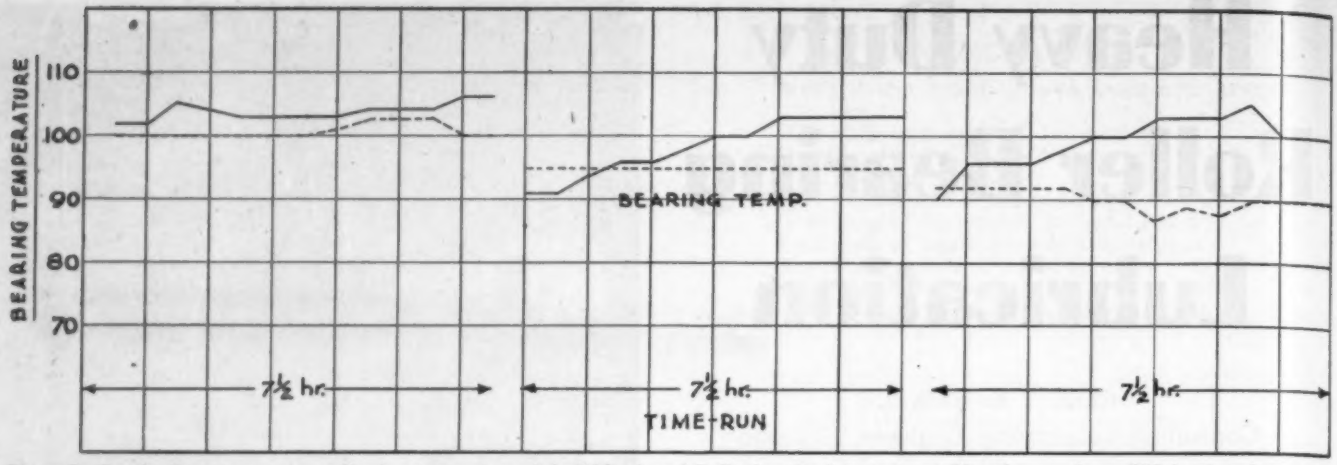


Figure 2—Result of test run on two roller bearing greases, A (solid line) and B (broken line) in tests at 80 miles per hour, 105.4 psi and covering 1811¼ miles.

bearing was 105.4 pounds and the speed was held constant at 80 miles per hour. Such tests will provide a satisfactory guide of what a ball or roller bearing grease will do in the larger diameter roller bearings. A special apparatus was used to pack the bearings, so that no air was entrained in the process of filling the bearing. The excess grease was removed, as it was found that a ball or roller bearing functions best on a minimum rather than an excess amount of grease.

Inspection after the test run showed balls or rollers and races of the bearings well covered with a shiney, smooth, soft and uniform grease film. Only a trace of oil separation was noticeable next to the hub, caused no doubt by the high centrifugal force of the bearing or due to the small amount of calcium-base grease incorporated in this type of mixed-base soap grease. These mixed-base soap greases usually show a trifle more oil separation in the bleeding test, than the straight soap greases.

Specifications furnished by a Class 1 railroad called for an ASTM-worked penetration of 250-300, (Class 68). This type of a grease calls for a combination of two soaps, having a 6-to-1 ratio of sodium to calcium soaps respectively. This combination of soaps in the finished grease usually prevents excessive increase in consistency of the sodium grease due to heat and working of the bearing. It also provides somewhat easier starting at the lower operating temperatures.

Three typical types of railway roller bearing units are shown in Figures 3, 4, and 5. The majority of these bearings are at present lubricated with oil. Just sufficient oil is put in the journal box to cover "half" of the lower roller, because if too much oil

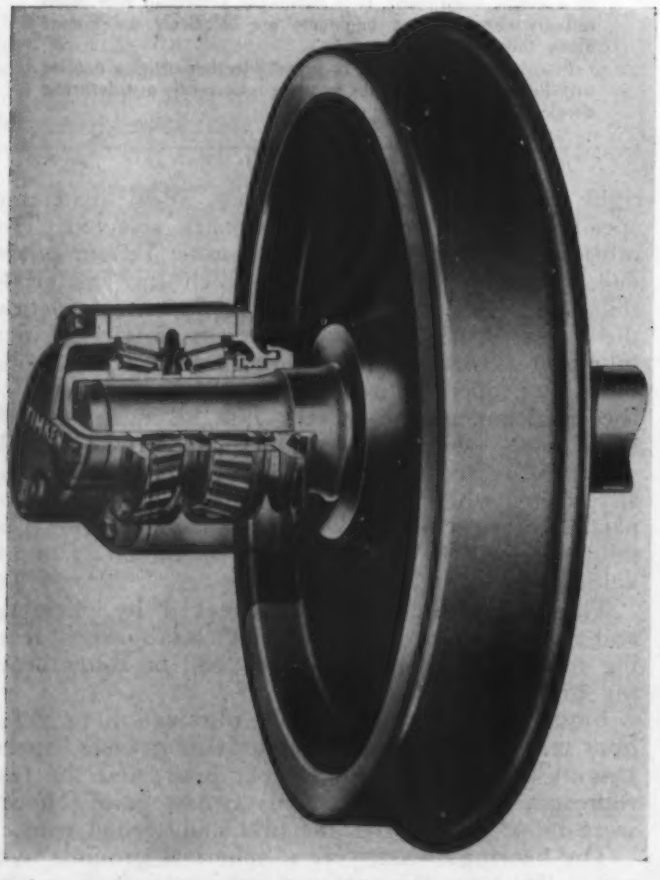


Figure 3—Bearing installation on railroad cars.

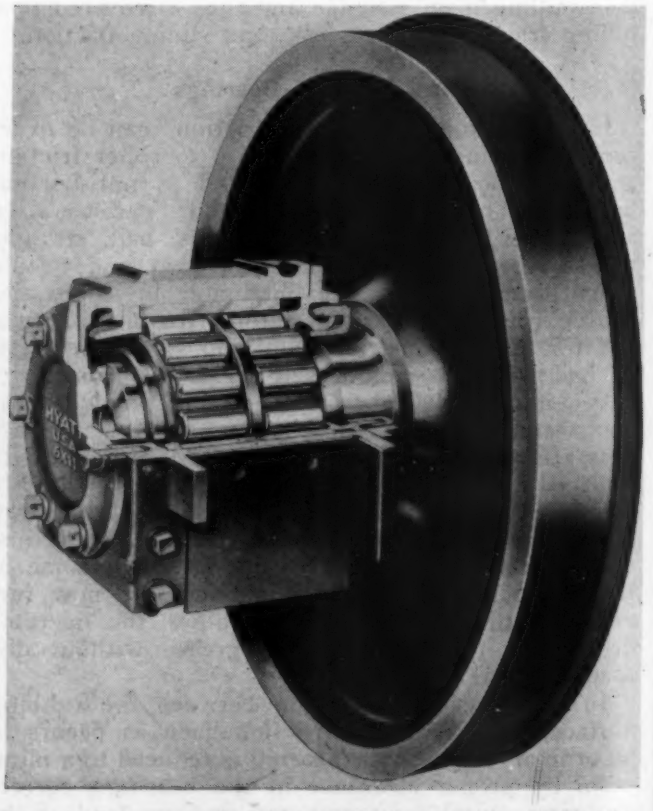


Figure 4—Cut-away section of latest roller bearing railroad journal box.

is added, the oil may foam or leak out too much in the back of the box.

Railroad car journal boxes in actual service on passenger and freight cars, including many high-speed interurban passenger coaches, may be equipped with roller bearings of three main types. A tapered roller design is shown in Figure 3, a parallel roller type with plain thrust bearing is shown in Figure 4, and an assembly which incorporates a ball bearing to take up thrust is shown in Figure 5. This spring-loaded thrust assembly is in contact with the end of the axle eliminating thrust bushing wear and putting pure thrust load on the anti-friction bearing.

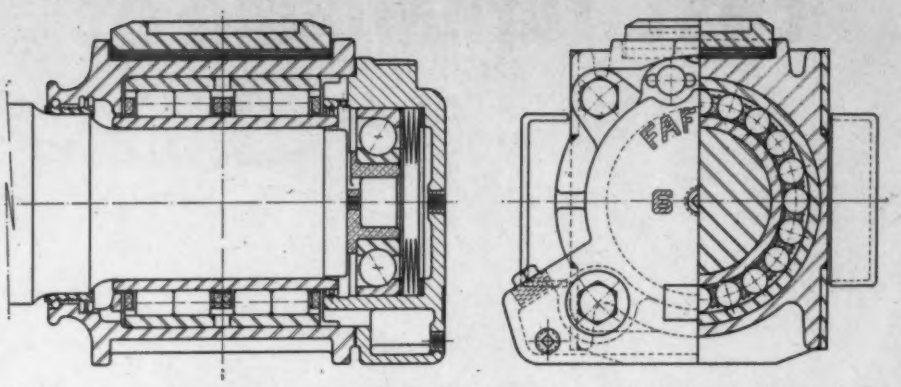


Figure 5—Railway journal box—an assembly which incorporates a ball bearing to take up thrust.

According to the AAR Lubricants Committee, tests are now being made at Indianapolis with different roller-bearings on specially designed equipment to compare load factor, efficiency of lubrication with various oils and greases, and temperatures developed during the tests. Accurate recording instruments are used on these comparative tests, so that they can be duplicated to compensate for variations on the different bearing units. Speeds and loads also can be varied. A special friction dynamometer has been developed for testing friction and to measure torque and tractive force. A refrigerating unit is essential to reduce temperatures to —30° F.

Both oils and greases are being tested. The oils selected for tests represent heavier oil, regular car oil, and special light car oil (low viscosity, low pour point oil with high film strength). The committee found that the greases are coming into the picture more and more as lubricants for roller bearings. This is no doubt due to difficulties encountered with oil lubrication, such as foaming, which causes bearings to run hot, or excessive leakage and additional service and checking operations required when roller-bearings are oil lubricated.

TABLE 1

Heavy-Duty Roller Bearing Grease

ASTM penetration, unworked	257
ASTM penetration, worked	267
ASTM dropping point	320° F.
Oven test—200 hr./150° F.	O.K., slight set up
Iodine value of fats	29.3
Corrosion test, on steel and copper	none
Accelerated bleeding test (100 hr./150° F.)	2.07%
ABEC test—all three temperatures	O.K. (.3 of 1 grm. leakage)
Bearing test spherical ground roller type (see Fig. 2), 966 rpm., Speed 80 mph.—105.4 psi., atmospheric temperature 80-86° F.— 1811¼ miles run, grease in bearing after test	53%
Grease on housing after test	47%
Grease used	none
Max. bearing temperature—Grease A	106° F.—Average 100.3° F.
Max. bearing temperature—Grease B	102° F.—Average 95.2° F.

Grease B	Ratio of Na to Ca—6:1
18.81% Sodium soap by weight	9.50% Beef tallow
2.72% Calcium soap by weight	7.00% Hydrofol No. 51
78.47% Mineral oil	2.31% Caustic flake lye +3.40% water
100.00%	65.19% Mid-Cont. oil, 400 SUS/100° F.
	16.00% Cup grease No. 3 (17% Cal. soap)
	100.00%

Oils used: 17.00% Mid-Cont. oil, 100 SUS/100° F. (in cup grease)
83.00% Mid-Cont. oil, 400 SUS/100° F.

100.00%

Viscosity at 100° F.	309 sec.
Viscosity at 210° F.	51 sec.
Specific gravity	25.8 Be
Color	3 minus
Kettle sample—ASTM Penetration, unworked	114
Kettle sample—ASTM penetration, worked	182
After 2 hours and 20 minutes milling (double action paddles) at 100° F.— ASTM penetration, unworked	257
ASTM penetration, worked	267
ASTM dropping point	320° F.

Appearance of grease, transparent, smooth, good feather, yet buttery.

The original applications of roller-bearings on railroad equipment were grease packed and if a suitable grease is used, they should require no checking of more than once every six months. These facts no doubt are causing the railroads to investigate suitable roller-bearing greases for more dependable grease lubrication for these units.

Table 1 shows physical data, formulae, and chemical analysis of a grease suitable for the lubrication of these units.

It has been found that at high speeds it is practical to use light oils and for slow speeds heavy oils. This is also true of oils which are incorporated into the ball or roller bearing greases, as heavy oils cause excessive drag and a corresponding loss in energy.

The iodine value and oxidation tendencies of the fats used in these greases; the bleeding test—50 hours at 150° F. or 48 hours at 210° F. are ideal for this test, while greases made with heavy steam-refined cylinder oils are sometimes specified to be tested for 200 hours at 275° F. which seems excessive both in length of time as well as in temperature. The ABEC test and exposure test of the finished grease, as well as the ball or roller bearing tests at various speeds and pressures are of greatest importance in evaluating a grease of this type. Although, no excessive high temperatures are encountered in this type of railroad grease, the ABEC test is also useful in checking other ball or roller bearing greases, such as, the light and medium grades of the AF bearing and wheelbearing greases. The leakage tendencies as well as the torque characteristics and adhesion to the bearing at 80°—150° and 220° F. temperatures, and with other physical grease testing equipment as recommended by the NLGI, give indications of what the grease in question will do in actual service. Low temperature torque tests should also be included, especially when greases are intended for aeronautical equipment.

The solvent treated parrafin oils are ideal for use in ball or roller bearing greases, however, combinations of small percentages of naphethnic or Mid-Continent oils compounded with Pennsylvania oils can be used if an oxidation inhibitor is used, but excessive high temperatures usualy affect most additives or inhibitors.

The new roller bearing equipped trains give much easier starting and smoother riding, but unless the locomotive engineer uses the air-brakes more cautiously, the object of these roller-bearing units is defeated, as quick application of air-brakes cause just as many jerks and jolts as though cars were equipped with ordinary waste-packed bearings.

First Turnaround of Leonard TCC Unit

JOHN S. PFARR, Technical Director
Leonard Refineries, Inc., Alma, Mich.

Catalyst lines were inspected for possible loss of metal due to erosion, and air and flue gas lines to and from the kiln were inspected to determine the condition of the internal insulation. No repairs were required. The condition of these lines is typified by the above picture which shows a section of the air inlet manifold to the kiln.

THE first turnaround of the new Leonard TCC unit has been completed with an expenditure of 4557 man hours, following an initial run of 222 days. The unit had an on-stream efficiency of 96.4 percent during the run. Using only 40 men per day, two crews of 20 men each, the work of the turnaround was completed in 10½ days. Of 40 men used, 29 were from refinery maintenance and 11 from operating personnel.

IN THE conclusion of the article upon which this somewhat condensed report is based, the author states:

"Naturally, from the day discussions were initiated concerning the installation of a catalytic cracking unit, we at Leonard have been concerned about turnaround man hours because we knew we could not undertake shutdowns requiring the number of man hours consumed in previous inspections of catalytic cracking plants. Leon Harris, the maintenance superintendent of the Leonard organization, spent much of his time during the construction of the plant familiarizing himself with the unit and planning for the first turnaround. He was confident that it could be done with his own small force. Mr. Harris now states that he is certain that on a year-around basis, the man hours of repair, maintenance and construction on the catalytic plant will be considerably less than that formerly expended on the thermal unit. A very large share of the credit for such a satisfactory inspection and turnaround should go to Mr. Harris and all of his foremen."

As a report from a group doing pioneer work in the operation of small scale commercial catalytic cracking units, this article should have high interest for many of our readers.

During the initial run there were several operating interruptions of short duration. See Table 1. Reasons for the off-stream periods were of minor nature and in total elapsed time of almost eight months, only 116 hours of off-stream time were attributable to the catalytic section of the plant.

To prepare the TCC plant for operation through the winter, a general turnaround was originally scheduled for late September. Heavy demand for refinery products necessitated that operation of the unit be continued for an additional month. To expedite the turnaround, a well-defined program of inspection was arranged in advance, Houdry and Leonard representatives scheduling the shutdown procedure and sequence of activities of mechanical crafts.

Since initial operation in March, 1947, the charge to the plant has consisted principally of Reed City and Adams reduced crudes which have sulfur contents of the order of 0.9 wt. percent. After preheating to about 840° F. reduced crude is flashed in a tar separator to produce vaporized feed for the catalytic reactor and a bottoms product which is subsequently processed into asphalt and fuel oil. Overhead and bottoms from the flash have average sulfur contents of 0.6 wt. percent and 1.1 wt. percent respectively. This sulfur content of the charge is sufficiently high so that some corrosion of processing equipment was anticipated. Results of the recent inspection, how-

A portion of the internal wall insulation and flue gas collector channel assembly in the bottom zone of the regeneration kiln is shown above, left. Above (right) is a view of the air inlet distributor channel assembly and water cooling coils of an intermediate zone of the kiln. A few panels of wall insulation in the kiln showed a slight amount of erosion. These were repaired with the field application of Panelclad, a new plastic insulation. No mechanical repairs were required on any of the air inlet distributing channels, flue gas collecting channels or water-cooling coils of the kiln.

ever, are particularly gratifying in that a minimum use of alloy steel for production against corrosion is indicated to insure the continued satisfactory performance of the plant.

The turnaround comprised a complete inspection of all items of equipment in the TCC plant—from the charge pump to the final stabilizer in the gas plant section. Pertinent data concerning the man hour requirements for the shutdown work are presented in Tables 2, 3, 4 and 5. Of particular interest is the fact that out of a total of 4557 man hours, 2954 man hours were spent in the inspection and maintenance of conventional refinery equipment such as valves, pumps, gas compressors, heat exchangers and fractionating towers and only 425 man hours were required for inspection and repair work on equipment in the catalytic section. Furthermore, the major portion of the work was accomplished with unskilled labor, as illustrated in Table 3. The distribution of man hours expended on the catalytic section according to items of equipment and also according to mechanical craft, is shown in Tables 4 and 5 respectively. Two of the work items performed during

The reactor was inspected for mechanical defects. Measurements indicated no loss of metal from the reactor shell or internal metal elements despite the fact that a relatively high sulfur content charge had been processed. This was particularly encouraging since all parts of the reactor are fabricated of carbon steel. Above photo shows a portion of the vapor and catalyst tubes of the disengager in the bottom of the reactor, and is typical of reactor internal condition. On the reactor wall above the catalyst bed a deposit of coke was found which was removed without difficulty.

TABLE 1

On Stream Efficiency Summary

Cause of Off Stream Time	Hours	Percent
Stabilizer clean-up	48.0	25.1
Blower maintenance	41.3	21.6
Circulating water pump failure	63.7	33.4
Power failures	26.7	14.0
Clay hold-up in reactor seal leg	11.3	5.9
Total	191.0	100.0
Total hours on stream 3-18-47 to 10-27-47	5140.2	....
Total hours elapsed 3-18-47 to 10-27-47	5331.2	....
On stream efficiency	....	96.4

TABLE 2

Manhour Requirement for Total Plant by Job Item

Job Item	Manhours	Percent
Turnaround		
Inspection and adjustments to catalyst elevator	75	1.7
Miscellaneous work on kiln and reactor	350	7.7
Sandblasting gas and water separator	285	6.3
Painting inside gas and water separator	48	1.1
Replacement of tar separator bottoms lines	501	11.1
Replacement of heater transfer lines	344	7.5
Miscellaneous work on valves, pumps, instruments, electrical equipment, gas compressors, heat exchangers, coolers, fractionating towers, etc.	2954	64.6
Sub-total	4557	100.0
New Installation and Revisions		
Liquid feed installation	275	....
Steam superheater piping changes	221	....
Total	5053	....

The new split bucket-type elevator functioned satisfactorily throughout the 222-day run and routine inspection and adjustment of the elevator required the expenditure of only 75 man hours. Here is shown a view of the elevator chain assembly passing over the head shaft at the top of the structure. The bucket partitions, chain links and traction rim may be seen. The baffles in the foreground of the view are the means by which the regenerated and spent catalyst contents of each bucket are diverted to the kiln and reactor hoppers respectively. Measurements of the loss of metal from the traction rims on the head shaft as well as from the elements of the chain links indicated that the elevator would operate for a considerable time before a major overhauling was required. For example, the total elongation of the chain during eight months of operation was four inches, equivalent to wear on each of the pin and bushing assemblies of a few hundredths of an inch. The chain knuckles, which contact the traction rims and are subject to more severe initial wear, showed an average loss of metal of about 0.06 inch and the traction rims themselves had lost only 0.017 inch of thickness. Following inspection, adjustments were made to the head shaft and the elevator was closed up for return to service.

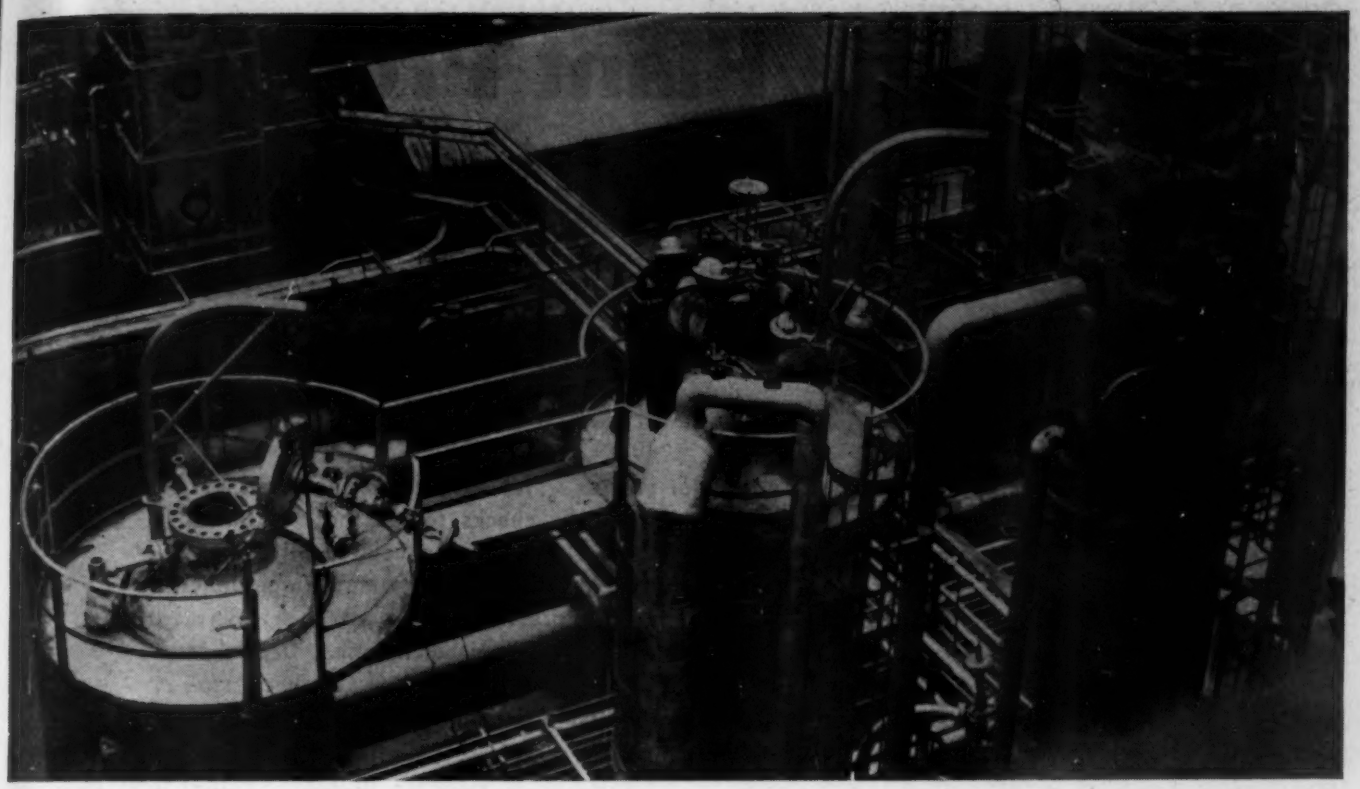
the shutdown do not come under the category of inspection and repair, since they involve changes in equipment design for new processing schemes to be employed in the plant. These were piping changes in the steam superheater section of the vaporizing heaters and the installation of liquid feed apparatus in the TCC reactor. Liquid feed apparatus requiring slight modification of the reactor internals was installed to permit the future processing of non-vaporizable stocks. The grand total man hours expended during the turnaround was 5053, 4557 for inspection and repairs and 496 for the above mentioned design changes.

Major items of repair were the renewal of sections of the transfer lines between the heaters and tar separator, the renewal of the hot tar lines from the bottom of the tar separator, and the cleaning and adjusting of wet gas compressors.

The wet gas compressors required thorough cleaning of both the power and compression sides. There were heavy sulfurous deposits on the suction valves of the compression cylinders. A large percentage of the 912 man hours charged by machinists during the turnaround was for maintenance required on the gas compressors.

Inspection of the gas and water separator tank revealed a slight pitting on those portions of the shell which are in contact with the water layer. This was corrected by sand blasting and a protective plastic paint. This equipment, incidentally, is not conventional. Instead of passing overhead vapors from the synthetic crude tower through the usual shell and tube condensers, a direct-contact, barometric

In original design study it was recognized that the sulfur content of the charging stocks to be processed might necessitate the use of alloy steel in many parts of the system. However, a decision was reached then to use carbon steel in several places and determine by experience those critical points where the use of alloy steel was necssary. The results of this inspection were gratifying in that severe corrosion was found to have occurred only in the heater transfer lines and tar separator bottoms lines. These lines were replaced with 4 - 6 percent chrome alloy steel. An interesting observation is that these lines operate within the critical temperature range for corrosion of carbon steel by the plant charging stocks. For example, the return line from the tar quench cooler to the tar separator showed no corrosion, whereas other tar lines which operate above 600° F. were severely corroded. Below shows the Houdry metal inspector calipering the return bends of the vaporizing heater tubes.



All fractionating towers in the plant were inspected and found in good condition. There was practically no coke or catalyst fines in the bottom of the synthetic crude tower, which speaks well for the efficiency of the catalyst-vapor disengager in the bottom of the reactor. This photo shows workmen engaged in removing the top head from the tar separator to permit inspection. A portion of the synthetic crude tower may be seen in the right foreground of the same photograph.

type condenser is used. Cooling water and hydrocarbon streams are discharged into a tank where separation of the condensed gasoline and water takes place. In addition to providing operating advantages, inspection of this equipment indicated that maintenance, material and labor was saved in comparison with usual practice. Based upon the experience of other refiners, the amount of hydrogen sulfide in the overhead vapors would probably have necessitated retubing condenser bundles after eight months' operation. It is fully expected that the barometric type condenser and the separator tank will last the life of the unit and require only minor repairs.

All coolers and heat exchangers were inspected and, where necessary, cleaned. There was not an excessive amount of fouling in any exchanger. The circulating quench exchangers were conspicuously free of any deposits of catalyst fines. The water sides of all water coolers were acidized.

A nominal amount of pump maintenance was required. Serious corrosion, similar to that which occurred in the hot tar lines, had also occurred in the hot tar pump, necessitating the replacement of fittings in the liquid end.

There was essentially no instrument maintenance required during the turnaround. The tabulated data show a total of 220 manhours for instrument servicing, of which a large percentage was expended in replacing orifice plates in the plant to accommodate the higher charge rates which have been and will be maintained.

TABLE 3

Manhour Requirement for Total Plant by Craft

Craft	Manhours	Percent
Turnaround		
Welders	200	4.4
Machinists	912	19.9
Instrumentation and electrical	216	4.8
General labor	3229	70.9
Sub-total	4557	100.0
New Installation and Revision		
Welders	302	....
Machinists	40	....
Instrumentation and electrical	4	....
General labor	150	....
Total	5053	....

TABLE 4

Manhour Requirement for Catalytic Section by Job Item

Job Item	Manhours	Percent
Turnaround		
Unheading and heading vessels, etc.	144	33.9
Elevator inspection and adjustment	75	17.6
Reactor clean-up	72	16.9
Repairing flue gas compressor	30	7.1
Instrument and electrical maintenance	24	5.6
Circulating water pump inspection and repair	18	4.2
Kiln insulation	16	3.8
Steam drum clean-up	12	2.8
Kiln clean-up	10	2.4
Make-up water pump repair	8	1.9
Miscellaneous	16	3.8
Sub-total	425	100.0
Liquid Feed Installation	275	....
Total	700	....

TABLE 5

Manhour Requirement for Catalytic Section by Craft

Craft	Manhours	Percent
Turnaround		
Welders	38	9.0
Machinists	85	20.0
Instrumentation and elctrical	24	5.6
General labor	278	65.4
Sub-total	425	100.0
Liquid Feed Installation		
Welders	180	....
Machinists	36	....
General labor	59	....
Total	700	....

Gasoline Plant Process Water Treatment

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WHILE the treatment of a particular process water once established does not vary greatly, it still is necessary to make periodic checks to see that treatment efficiency is being maintained, and that personnel are fully acquainted with treatment problems. This paper reports briefly on such a survey recently made in gasoline plants operated by a major company in the Tulsa area.

This presentation was before the Panhandle Plains Regional Meeting, December 12, 1947, at Amarillo, Texas, first regional meeting of the Natural Gasoline Association of America. J. S. Connors, Phillips Petroleum Company, Borger, Texas, gave a prepared discussion, which follows this paper.

SEVERAL years ago, it was the writer's privilege to set up a series of water treatments for these various plants and to instruct men, chosen by the plant superintendents, in the method of treating to be used, together with the tests necessary to control these treatments. Each plant was supplied with a copy of a handbook[1] outlining standard tests and the methods used to make them.

In instructing the men, most of whom were not chemists, the use of chemical terms was purposely avoided, in order to build up confidence. Any man who can distinguish color and can add figures, can be taught to do a good job in controlling water treatment. By going into too much chemistry at first, you can cause a man to think that the process is too involved for him to handle and he does not even try. However, after a while with routine tests, most men become curious and want to know what or why they are doing certain things. Most men now making tests and controlling water treatments have reached that point. They all have been doing a good job and when the treatment goes wrong they have general knowledge of what to do to correct it. Several of them have existing conditions that are beyond their control and will have to be satisfied with the water that is treated only approximately correctly. Some of these conditions may be corrected, while to correct others may not be economically sound.

It was a pleasure to note that several of the men have become so interested that they have purchased chemistry books to study further the art of water treatment. Unfortunately, most chemistry books do not cover water treatment specifically and it takes a lot of reading and studying of other subjects to get what is finally required. It is suggested that these men be supplied a manual[2], which gives in a condensed form, a practical treatise on how to determine the cause of boiler scale and how to maintain clean heating surfaces together with instructions for testing and treatment. This book would satisfy both the engineer and the layman.

In general water treatment,[3] as known in these plants, consists of either lime and soda ash (cold process) batch treatment, or a zeolite treatment, or no treatment at all for raw water. In two plants lime and soda ash treatment is used as the original treatment. This is followed by an after treatment of phosphate in combination with tannin in boiler and cooling water. One of these plants has continuous blowdowns on the cooling water system, while both have continuous blow-downs on the boilers, and use algaecide treatment to keep down algae and slime.

In the lime and soda ash treatment the hardness of the water together with suspended matter is precipitated as sludge thereby reducing the total solids in the water to be used in the various systems.

In two other plants a zeolite water softener is used as initial treatment of the raw water, which in both cases is followed by phosphate and tannin in the boilers. One uses acid treatment in cooling water and the other uses Scale X as a treatment, and both plants use algaecide for the control of algae and slime.

In controlling algae,[4] regardless of what type of algaecide is used, in time the vegetable growth will become immune to that chemical. It is then necessary to use another algaecide for a period of time, after which the original may again be used. Inasmuch as copper sulphate is one of the cheapest algaecides, it is most generally used. When algae becomes immune to copper sulphate, the plants have been using sodium pentachlorophenate, until such time as copper sulphate again becomes effective. The use of any algaecide should be started before too much algae is present or it may result in the killing of a large amount of algea which will float in the water through the system and probably clog up some of the water passages, causing extensive shut downs

and expensive cleanout jobs. If this treatment is not started early, a small amount of chemical should be used at the first so that all algae will not be killed at one time. The treatment can be gradually increased until finally all algae is destroyed.

Secondary treatment of cooling water can be handled in one of two ways; either convert to sulphate the carbonate which is formed by the liberation of Co_2 from the bicarbonate radical, or hold the carbonate in solution. In the latter case the calcium carbonate must either be held in solution by chemical means or controlled by continuous blow-downs so that the concentration, due to evaporation of water, windage loss, etc., in the tower, will not build up to a point where the calcium will precipitate. Calcium carbonate precipitation forms a hard scale on the metal thereby reducing the heat transfer in the cooling system. The solubility of this compound is very low being approximately 92 ppm at 32° F. about 15 ppm at 212° F. and about 10 ppm at 356° F.

Conversion of Carbonate Radical

When conversion of the carbonate radical is employed, this is generally accomplished by the use of relatively cheap sulphuric acid. Calcium bicarbonate thus is converted to the more stable and soluble calcium sulphate. At the temperatures normally encountered in cooling water, we can safely carry 1200 to 1600 ppm of calcium sulphate without serious precipitation. This also allows us to increase the concentrations of total solids that may be maintained in our cooling systems.

A comparison between untreated and treated cooling water is given by Betz, as follows:

	Raw	Untreated	Acid-Treated
Total hardness as $CaCO_3$	75	135	510
Sulphate as SO_4	20	60	1265
Alkalinity to methyl orange as $CaCO_3$	200	600	250
Calcium as $CaCO_3$	50	65	340
Magnesium as $CaCO_3$	25	65	170
Blowdown gpm	....	57	7
Makeup gpm	....	225	175
Cycles of concentrations	....	3	7

With 50 ppm of calcium present in the raw water and three cycles of concentration, the circulating water should have contained 150 ppm if none had precipitated to form scale or sludge. Actually, 65 ppm of calcium is present which means 85 ppm has precipitated as scale. With the acid-treated water, it can be seen by comparison, that the methyl orange alkalinity has been limited to 250 ppm whereas the sulphate content of the water has been sharply increased to 1265 ppm. With 50 ppm of calcium in the raw water, 350 ppm would be expected in the water having seven concentrations. Actually, it was found that 340 ppm of calcium was present, which represents 97 percent maintained in a soluble form. One big advantage of the acid treated water, therefore, was the retention in solution of scale forming material. An equally important point, however, is that 50 gallons per minute, or 22.2 percent less make up water was required due to the reduction in blowdown losses made possible by carrying higher concentrations of total solids. In many gasoline plants where water is a scarce material, this is important.

All of the boilers in the plants have continuous blow-downs and most of them are using phosphate and tannin as an internal treatment to condition sludge and to correct for caustic embrittlement. These boilers are being operated from 30 to 160 days without cleaning out whereas before internal treatment they were cleaned out every 30 days, as a regular routine. Some of these boilers now, even after 160 days operation, cause little "cleaning out" trouble. More time is consumed in cooling off and bringing the boiler back to pressure than in cleaning.

In one plant, water is furnished from shallow wells operated by another department. Water is pumped into two 1600-barrel steel treating tanks located in the plant yard where it is treated with lime and soda ash for softening. Ferric sulphate is used as a coagulent to weight down and hasten settling of the fine precipitant formed by the lime and soda ash.

The chemicals are mixed with water in a steel container, thoroughly agitated and transferred to the full settling tank by means of a steam injector. Water in the settling tank and the chemical charge are then mixed by air agitation after which the treated water is allowed to settle for a minimum of eight hours. It is then drawn off by means of a swing pipe, which allows the top water in the tank to be drawn first and discharged into the engine jacket hot well located at the southwest corner of the compressor building. From here it is pumped through the engine jackets and to the bottom ring of a 55,000-barrel steel tank located south of the plant yard. A portion of the treated water is pumped to the hot well serving the boiler plant. The cooling water make-up is from the engine jacket system.

Batch Treatment Not Ideal

This is not an ideal condition. In the first place, it is the batch treatment, (a quantity of water is treated, settled, and then added to the system all at one time.) This water is then circulated until the next batch is ready, which is a minimum time of eight hours. One of the worst features of this practice is the fact that treated water is dumped into an open-top concrete pit that is level with the ground elevation. Dirt and weeds naturally get into this pit. Several years ago approximately 18 inches of mud were removed from this pit and now approximately 14 inches more have accumulated. Even though the suction of the circulating pump is screened, considerable mud goes through the system and into the large steel tank which has several feet of mud in it. Some time ago an attempt was made to clean this out but when the mud was removed, the tank bottom began to leak so badly that, rather than to go to the expense of repairing the tank, the effort was abandoned. Considerable mud gets from the hot well into the boilers requiring that they be shut down approximately every 30 days to clean the mud off the crown sheet. Excellent operating conditions exist except for this mud. From these tests and information from the plant operators, it was indicated that there is no scale in the boilers. If it were possible to eliminate the mud from the boiler make-up water, the writer believes that instead of 30 days, these boilers could be operated 60 to 120 days without clean outs.

The boiler feed hot well is a horizontal tank set on a pipe frame. It was suggested that a 4 inch collar be welded into one end of this tank with the bottom of the collar approximately 4 inches off the bottom of the tank. A 4-inch pipe would be placed inside the tank and 41 5/8-inch holes drilled on 6-inch centers throughout the length of the pipe. The holes would be staggered on a 45° angle from the center line of the pipe, installed looking down, and a quick

opening valve placed on the outside of the tank and connected to the sewer. This valve would be operated as often as necessary to keep the mud in the hot well to a minimum. It is recognized that this will be a make-shift method, but it may reduce the mud going to the boilers so they can operate for a longer period, thus saving shut-down time, and freeing for other plant operations labor now used to clean out the boilers.

Another of the plants showed excellent results. The concentration in the cooling water, the engine jacket, stabilizers and distillation unit were 3 to 8.6. The methyl orange alkalinity is 152, 350 and 470 ppm, respectively. Higher concentrations should be carried if acid treatment were used on this water, thereby reducing blow-down and consequent make-up water. This would also lower methyl orange alkalinity and minimize scaling tendencies now present.

Too Much Blow-Down

The water in all the boilers, except two, was in excellent condition. No. 5 boiler had just been put on the line after having been stored full of undiluted make-up water for 21 days. The methyl orange alkalinity of the water in this boiler was 1016 ppm, and the concentrations were 17.3, whereas an attempt is made to maintain a maximum of 500 ppm of methyl orange alkalinity and around 250 ppm of phenolphthalein. One other boiler had only 3.3 concentrations and methyl orange alkalinity of 280 ppm, which indicated that it had too much blow-down.

In a third plant the boiler water as far as methyl orange alkalinity was concerned was pretty much in line with the exception of one boiler. This was found to have a stopped continuous blow-down which was opened up so that it would function properly. The PO_4 radical was somewhat low, ranging from 5 to 20 ppm in place of the recommended 35 to 60 ppm phosphate as PO_4. The chloride concentrations of these boilers were being maintained at 4 to 5. This is necessary because of the high total solids due to the raw water being of the zeolite-treated type in which the treated water actually has an increase of total solids over the raw water.

Another Plant's System

The cooling water in another plant is treated with sulphuric acid. The methyl orange alkalinity in the jacket system was found to be 146 ppm and in the other system 240 ppm. The chloride content was 240 ppm in the jacket system, and 680 ppm in the other. The methyl orange alkalinity in the water from the zeolite softener, which is used as make-up water for these two systems, was found to be 300 ppm, while the chloride was 120 ppm. This means that the jacket water has two concentrations while the other water has 5.65. The methyl orange alkalinity of both systems was well within the range of 250 ppm.

The boilers here have a methyl orange alkalinity of 612 to 910 ppm. The phenolphthalein alkalinity was from 512 to 790 ppm. The phosphate as PO_4 was 5 to 15 ppm. The writer feels that this phosphate radical should be higher, but, the operators at this plant say that there is very little scale in the boilers, no pitting, and they are able to operate from 160 to 190 days without shutting down, which certainly is good service.

At another of the plants no treatment is used except internal water treatment for the boilers and algaecide for cooling water. Tests on the first days indicated that the methyl orange and phenolphthalein alkalinities of these boilers were extremely high while the phosphate was 25 to 45 ppm. Two days of excessive bottom blow-down reduced these alkalinities but not sufficiently to be satisfactory. Instructions were left with the operators to continue bottom blow-down until the alkalinities were reduced to a methyl orange alkalinity of approximately 500 ppm in each boiler. The coil pit at this plant showed very little algae and scale, these being controlled with copper sulphate augmented with Santobrite, and blow-down, when necessary.

The pH value of the cooling water in the 85 H. P. engine was found to be 8.8. This engine is cooled with distilled water, treated with soda ash to produce a minimum pH of 8.5 after which sodium dichromate in the amount of 500 ppm is added. This imparts a dark yellow color to the water. A sample of water from the engine was found to be light yellow in color, which indicated a deficiency of sodium dichromate. It was recommended that additional chemical be added.

Tests on the 145-hp. engine showed the pH to be 9.0. The color for sodium dichromate seemed to be all right. However, there was quite a sludge in the sample bottle. Suggestions were made to drain and flush this system, and re-charge with treated water.

Water Pumped Without Treatment

Water furnished the last plant visited is pumped from a lake without treatment, to the engine jacket and boiler systems. Boiler water is internally treated with soda ash and sodium aluminate. The methyl orange alkalinity in the boilers on the first day was 436 to 1028 ppm. The phenolphthalein alkalinity was from 352 to 808. By excessive bottom blow-down, the methyl orange alkalinity in boiler No. 1 was reduced from 1028 to 836 ppm.

Alkalinity in boilers Nos. 2 and 3 increased during this time, probably due to the large amount of insufficiently treated raw water added to the system to compensate for the excessive blow-downs. All three boilers were then blown-down excessively by bottom blow-down the next day, resulting in a methyl orange alkalinity of 152 to 220 ppm, which was too low. Instructions were left to reduce bottom blow-down, depending on the continuous blow-down, until the methyl orange alkalinities reach 500 ppm.

Copper sulphate is the algaecide normally used in the coil pit at this plant. Some immunity had been built up to this material and the use of a different chemical was desired by the superintendent. Since the operators must enter the coil pit at frequent intervals to make repairs, the temporary use of copper chloride was suggested.

Naturally, it will be recognized that the foregoing deals not with the latest water treating methods, and water plant system design but is rather an attempt to show what can be done to improve operating conditions in plants using older treating equipment along with the various chemicals now available. This, however, is an important phase of plant operation where capital expenditures are out of the question and operating costs must be held to a minimum.

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Discussion of

"Gasoline Plant Process Water Treatment"

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MR. HUTCHESON'S paper of necessity covers a wide field and many phases of water treatment. In this discussion the writer believes it would be of greater benefit to more thoroughly cover the potentialities of some of the water treating problems and methods mentioned than to merely agree or disagree with Mr. Hutcheson's presented data and conclusions. Especially since it is generally agreed that there are many ways of satisfactorily treating water and the method and means selected will to a large extent depend on the economics of the problem. It is a well-known fact that the most common ground for all water treating engineers is that they are all agreed to disagree.

It should be recognized that any reliable method of water treatment will be only as satisfactory as the control of such treatment is accurate, frequent, and sufficiently comprehensive. The two publications mentioned are accepted as reliable standards by most plant water treating chemists and engineers. However, a third publication[1] should be added to the list that all plant superintendents should have available.

Methods of Boiler Water Treatment

There are three methods of boiler water treatment in general use, together with seemingly endless modifications and variations to fit specific cases. However, regardless of the method of treatment selected, it is extremely important to make every effort to condense and return all steam possible to the boiler house. This saves water and consequently reduces the treating bill. A short discussion of the merits of each method of treatment is as follows:

I) Lime-Soda Softening—followed by phosphate and organic after treatment.

A) Hot Process Deaerating Softeners. Water softened by this method will have a soap hardness of approximately 0.5 to 1.0 grains per gallon with a total alkalinity of 3.5 to 4.5 gr./gal.

The advantages of this process are as follows: 1) Oxygen is practically eliminated. 2) The silica content of the water is reduced. 3) Alkalinity is lowered and bicarbonates are removed. 4) Total solids are reduced. 5) Phosphate after treatment requirements are low. 6) Low treating cost. 7) Low boiler maintenance and water make-up.

The disadvantages are as follows: 1) High initial investment. 2) Only moderately flexible.

B) Cold Process. Water softened by this method will have a soap hardness of approximately 1.0 to 2.0 gr./gal. with a total alkalinity of 4.5 to 5.5 gr./gal.

The advantages of this method are as follows: 1) Silica content is reduced. 2) Alkalinity is lowered and some bicarbonates are removed. 3) Total solids are reduced. 4) Low treating cost. 5) Low boiler maintenance and make-up.

The disadvantages are as follows: 1) Oxygen is not removed. 2) Phosphate after treatment requirements are relatively high. 3) Relatively high initial investment.

II) Zeolite softening followed by phosphate and organic after treatment.

(Water softened by this method will have a soap hardness of approximately 0—.5 gr./gal.)

The advantages of this process are as follows: 1) Relatively low initial investment. 2) Low phosphate after treatment requirement.

The disadvantages are as follows: 1) Oxygen is not removed. 2) Silica is not removed and is rendered more liable to deposition within the boiler as a hard glass-like scale. 3) total solids are increased. 4) Alkalinity is not lowered and the tendency toward caustic embrittlement is increased. 5) Relatively high chemical treating cost. 6) Relatively high boiler maintenance and make-up.

III) Internal softening with phosphates, soda ash or mixtures of the two, together with organic material.

The advantages of this method are as follows: 1) Practically no initial investment. 2) Extreme flexibility.

The disadvantages are as follows: 1) Oxygen is not removed. 2) High chemical cost. 3) High make-up requirement. 4) Relatively high boiler maintenance.

Results Obtained With Hot Lime-Soda Treating

At one of Phillips' Panhandle plants where the water to be treated has a hardness of 11.8 gr./gal. with a total alkalinity of 11.4 gr./gal., the chemical treating costs are approximately 9 cents per 1000 gallons of water treated. The Softened water has a soap hardness of approximately 1.0 gr./gal., with an alkalinity of only 3.0 gr./gal. The boilers are inspected once a year and are found to be free of scale or corrosion. However, as a matter of routine precaution, the tubes are mechanically cleaned at this time.

The total boiler feed water consists of approximately 85 percent steam condensate and 15 percent softened water. A mixture of anhydrous disodium phosphate and liquid tannin is injected into the boilers twice each tour to maintain a phosphate residual of 20-40 ppm in the boilers at all times. The plant has 8 145 hp. 148-pound water tube boilers firing at approximately 210 percent of rating. The burners are of the fan mix type with 25-30 pounds of pressure on the fuel line. Because of the high rate of firing the total solids in the boiler are controlled between 50 and 60 gr./gal. to prevent entrainment of the boiler water in the steam produced. Table 1

shows typical plant operating data. It should be noted that plant operators perform all boiler tests once a day and test the softener effluent each 4 hours.

Results Obtained With Zeolite Treating

Since straight zeolite treating was considered impractical on Panhandle waters and abandoned some years ago, I shall not attempt to give obsolete data from this type of operation.

However, as an example of how zeolite treating can be advantageously combined with other methods to take advantage of the best features of all, the writer wishes to refer to one plant where all the plant water is processed in a continuous cold lime-alum treater. A portion of the effluent from this treater is further treated with sulfuric acid for pH control, and this treated water is used for cooling tower make-up. The balance of the water from the cold lime-alum treater to be used for boiler feed water make-up is then zeolite softened, using carbonaceous zeolite on the sodium cycle. The water is then deaerated at high temperature where oxygen and carbon dioxide are removed before it is used as boiler make-up water.

It is regretted that time did not permit the assembling of operating data on this particular operation. However, the boilers are fed a mixture of 50 percent condensate and 50 percent soft water. The normal time on stream is one year and upon inspection the boilers are found to be scale free. The abnormally high boiler make-up requirements at this plant are due to a large demand for process steam and from which the condensate cannot be recovered in a usable form. It is significant that even with the high make-up requirement, the alkalinity in the boilers can be controlled between 29-35 gr./gal. without excessive blow-down.

Results Obtained With Internal Treating

At another Panhandle plant where the make-up water has soap hardness of approximately 8.0 gr./gal. with an alkalinity of 10 gr./gal., the chemical treating costs are approximately 13 cents per 1000 gallons of make-up. The boilers are inspected and require cleaning after 22-26 weeks on line.

The total boiler feed consists of 33 percent raw make-up and 67 percent return condensate. Chemical is fed continuously into the hot well. The plant has 8 145 hp. 148-pound working pressure water tube boilers firing at 138 percent of rating (7 on line). Gas burners are used with 10-12-pound pressure on the fuel line. The total solids in the boiler are controlled at 80-100 gr./gal. to prevent carry-over. In this plant approximately 35,000 gallons per day of steam condensate (excess dephlegmator water) is being sent to the cooling tower since it contains some 43 ppm of mineral seal oil which, if returned to an internally treated boiler, will cause the boiler sludge to bake on the tubes producing a semi-scale which in turn causes tube failures. Table 2 shows typical operating data from this plant. Table 3 shows the true comparison between the chemical costs of treatment between the two plants presented as costs per 1000 pounds steam produced.

Cooling Tower Operations—Softened Water Make-Up

There are many advantages in using a softened make-up for cooling tower operation. However, when soft water make-up is used as a means of preventing scale formation, care should be exercised that replacement of materials damaged by corrosion does not offset the advantage gained by reduced scale formation. For example, the effluent water from a cold process lime-soda treater is stable and any increase in temperature will cause additional precipitation of hardness due to the shifting of the chemical equilibrium of the constituents. This is usually offset by recarbonation with either sulfuric acid or carbon dioxide. A water which has been softened and recarbonated is always corrosive and careful control of the concentrations is necessary to bring the system back into equilibrium.

Similarly, zeolite softened water is normally corrosive and has such a high alkalinity that after concentration and heating the excessive quantity of sodium carbonate present will cause rapid delignification of the tower itself.

TABLE 1

Boiler Treating Data Sheet

(Grains per Gallon)

SAMPLES	Dissolved Solids	NaCl	Soap Hardness	P	M	O	S	N
Treated water	..	1.2	.9	1.1	2.8	—.6	1.9	1.3
Boiler feed	..	.2	.3	0	.9	0	.6	0
Boiler No. 1	49	8.2	0	13.8	15.7	11.9	15.7	3.8
Boiler No. 2	49	7.6	0	13.0	16.1	9.9	16.1	6.2
Boiler No. 3	68	11.1	0	18.5	21.5	15.5	21.5	6.0
Boiler No. 4	67	10.5	0	17.5	20.6	14.4	20.6	6.2
Boiler No. 5	52	9.2	0	14.7	17.7	11.7	17.7	6.0
Boiler No. 6	56	9.7	0	16.6	19.1	12.9	19.1	6.2
Boiler No. 7	49	5.7	0	13.0	15.8	10.2	15.8	5.6
Boiler No. 8	34	5.0	0	9.2	11.2	7.2	11.2	4.0

Water Treated ..... 30,372 GPD
Steam, Produced ..... 84,000 pounds/hr.
Rated Blr. HP Operating 1,160
Boiler Efficiency, percent 214
Daily Chemical Consumption:
Hydrated Lime ..... 54 pounds
Soda Ash ..... 14.4 pounds
Disodiumphosphate ..... 12.0 pounds
Liquid Tannin ..... 3.0 pounds

TABLE 2

Boiler Treating Data Sheet

(Grains per Gallon)

SAMPLES	Dissolved Solids	NaCl	Hardness	P	M	O	S	N
Raw water	20.0	2.0	8.4	0	10.0	0	1.6	..
Boiler feed	5.0	0.5	1.0	1.0	2.8	0	.8	..
Boiler No. 1	75	18.2	0	39.9	43.4	36.4	43.4	7.0
Boiler No. 2	75	19.0	0	40.1	44.2	36.0	44.2	8.2
Boiler No. 3	80	25.0	0	43.9	47.5	40.3	43.9	7.2
Boiler No. 4	63	20.9	0	33.3	37.3	29.3	33.3	6.0
Boiler No. 5	110	33.0	0	59.3	65.3	53.3	65.3	12.0
Boiler No. 6	43	9.2	0	22.5	25.6	19.4	25.6	6.2
*Boiler No. 7	20	5.0	0	11.2	12.4	10.1	12.4	2.4
Boiler No. 8	100	25	0	52.8	59.0	46.6	59.0	12.4

* Just coming on line.
Water Treated (Make-Up) ..... 50,000 GPD
Steam Produced ..... 47,500 pounds per hr.
Rated Blr. HP Operating 1,015
(Boiler coming on line not included)
Boiler Efficiency, percent 138
Daily Chemical Consumption:
Boiler Compounds No. 3100 ..... 36 pounds
Antifoam No. 78 ..... 4.5 pounds
Liquid Tannin ..... 4.5 pounds

TABLE 3

Chemical Cost Per 1000 Pounds of Steam Produced

	Steam Produced Per Day, Lbs.	Chemical Cost Per Day	Chemical Cost Per 1,000 Lbs. Steam
Hot lime soda softened make-up	1,980,000	$2.70	$.00136
Internally treated	1,140,000	6.50	.0057

Methods for Determining Stability

Several methods have been proposed by which the tendency of the water to either dissolve or precipitate calcium carbonate may be calculated. Professor

W. F. Langlier proposed that the tendency of the water to form scale or to corrode could be calculated by the formula pH-pHs = saturation index in which a positive number indicated scale formation and a negative number indicated corrosion. The greater the value the greater the tendency. T. E. Larson and A. M. Buswell modified Langlier's method for calculating the pHs. The latter method is accepted as a standard, for want of a better, and tables for determining the pHs of any water are available. Later Dr. John Ryznar proposed that for recirculated waters the Langlier index should be modified so that the tendency to scale or corrode could be calculated by the formula 2pHs - pH = stability index. In this method all values are positive and values for the index above 6.5 indicate a corrosive tendency while values below 6.0 indicate an increasing tendency toward scale formation.

Examples of Stability Calculations—Soft Water Operations

As an example of these methods of calculation, a Panhandle water which has been lime-soda softened and recarbonated with sulfuric acid might have the following significant composition:

COMPONENT	Gr./Gal.
Dissolved Solids	8.2
Total Soap Hardness	.9
Calcium Hardness	.2
NaCl	1.2
Na_2SO_4	2.0
Total Alkalinity	2.0
pH	7.2
pHs	9.5

Langlier's Index:
pH—pHs = 7.2—9.5 = 2.3 (Corrosive)
Ryznar's Index:
2pHs—pH = 2x9.5—7.2 = 19—7.2 = 11.8 (Corrosive)

Now assume that this water is concentrated 8 times and the composition will be:

COMPONENT	Gr./Gal.
Dissolved Solids	65.6
Soap Hardness	7.2
Calcium Hardness	1.6
NaCl	9.6
Na_2SO_4	16.0
Total Alkalinity	16.0
Predicted pH	9.3
pHs	7.7

Langlier's Index:
pH—pHs = 9.3—7.7 = 1.6 (Scale Forming)
Ryznar's Index:
2pHs—pH = 2x7.7—9.3 = 15.4—9.3 = 6.1 (Very slightly scale forming)

It is obvious that in either of the above cases only a very small amount of calcium is available for scale formation.

Cooling Tower Operations—Raw Water Make-Up

Where raw water is used as cooling tower make-up and treated with sulfuric acid to control the alkalinity in the tower pits, similar calculations can be made to show the tendency for the concentrated water to be either scale forming or corrosive. The objection to this method of treating is the excessively close control of both alkalinities and concentrations required. As an example, using a raw make-up water having a pertinent composition as follows:

COMPONENT	Gr./Gal.
Dissolved Solids	16.0
Soap Hardness	11.4
Calcium Hardness	5.8
NaCl	1.5
Na_2SO_4	1.5
SiO_2	1.1
Total Alkalinity	11.5

This water, when sulfuric acid is added to maintain a total alkalinity in the tower pit of 6.3 gr./gal. can only be concentrated 2.75 times without scale formation, but if the alkalinity is maintained at 4.8 gr./gal. the allowable concentration is 6.0. By treating with sulfuric acid to maintain alkalinities of 12-16 gr./gal. and adding one of the molecularly dehydrated polyphosphates stabilized with organic compounds, the concentrations can be varied from 5-8 without either scale or corrosion.

Algae Control

Most proprietary algaecides contain copper in some form as the active ingredient. The most common algaecides in use are copper organic compounds, copper sulfate, potassium permanganate, sodium pentachlorophenate and chlorine. Algae and slimes will slowly build up an immunity to most of these treatments much as the human body can develop a tolerance for arsenic, and it is necessary to vary the type of algaecide used. It is important to add treatment in large killing dosages in slugs of 20-40 ppm at one time rather than to add small amounts continuously. It should be noted that when copper sulfate is to be used to the best advantage the pH of the cooling system should be reduced to approximately 7.0 before the copper sulfate is added.

Corrosion Control

The use of corrosion inhibitors is becoming more general. Water which is non scale forming but corrosive may be successfully inhibited against corrosion by the use of organic chromium compounds or the sodium chromates. The organic chromates are more effective than the straight inorganic chromates. pH control is also important, the pH necessary for good protection where sodium chromate is used being 8.5 to 9 while the organic chromates can be used at a much lower pH.

Conclusion

It is hoped that this method of discussing Mr. Hutcheson's paper by presenting additional theory together with application and operating data will be satisfactory and can be construed as both constructive criticism and a contribution to the subject in general.

REFERENCE

[1] The Data Book, compiled by The Permutit Company.

* * *

Control of Narrow Boiling Range Fractionating Columns

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PRESENT day petroleum refining practices are working toward a higher and higher degree of separation of the narrow boiling-range hydrocarbons. More accurate and more direct methods of instrumentation and control are required. In this brief article the author outlines the problems involved in terms of the product composition changes for small temperature and pressure changes, discusses results obtained with a vapor pressure controller on binary columns, and concludes that, "several years after development of a need for a better means of controlling the multi-component columns, undesirable indirect methods are still being used because a satisfactory direct composition controller was unavailable. This is a definite challenge to the instrument industry to intensify its research and development along these lines."

Presented before the Chicago Section of the Instrument Society of America, February 3, 1947.

THE usual means of temperature and pressure control, long used on ordinary fractionating columns are not adequate for the super fractionators now encountered.

Figure 1 shows a deisobutanizing column which fractionates isobutane from normal butane.

At 110-psi. column pressure, there is only 23° F. difference between the boiling point of pure isobutane and that of pure normal butane. On this basis a change of only 1.0° F. in column temperature will cause a change in composition of approximately 4 percent. From this it can be seen that the accuracy required is hardly possible with present day temperature controllers. Even then, holding the temperature alone constant will not suffice since the purity of the product overhead may also vary in the order of 2 to 3 percent with a change in pressure as small as 1.0 psi. Changes in barometric pressure alone can be responsible for variations of several percent in the purity of the overhead material. From this it can be seen that it is important to maintain *both* pressure and temperature within very close limits. Since temperature and pressure controllers with the required accuracy were not available, a search was made for a better method of control. What was most desired was a composition controller that would make the necessary adjustments to the process for variation in column temperature, pressure, feed composition or feed quantity.

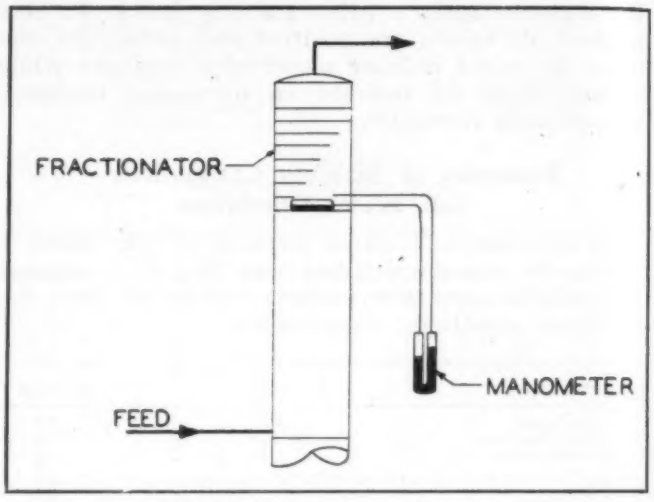


FIGURE 2—Vapor Pressure Balance.

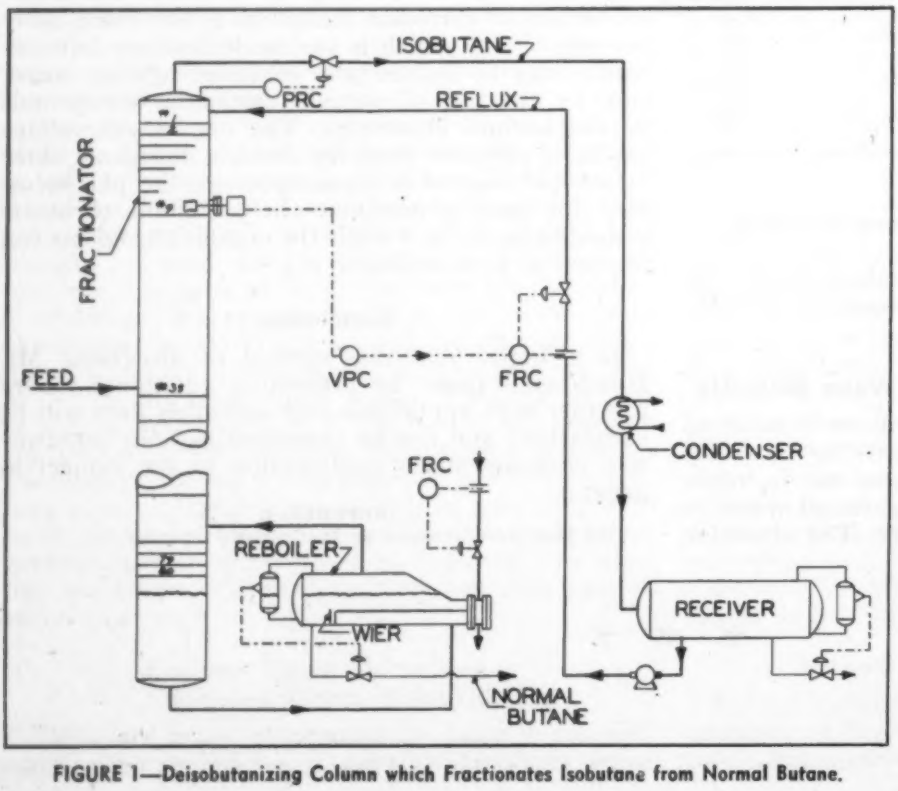


FIGURE 1—Deisobutanizing Column which Fractionates Isobutane from Normal Butane.

One method which has been developed for controlling such narrow boiling range columns is commonly known as a vapor pressure controller, although on strictly *binary* columns it is essentially a *composition controller.* This instrument consists of a temperature bulb and pressure connection, both being located at the same point in the column (Figures 2 and 3). The temperature bulb is partly filled with one of the materials being fractionated. This

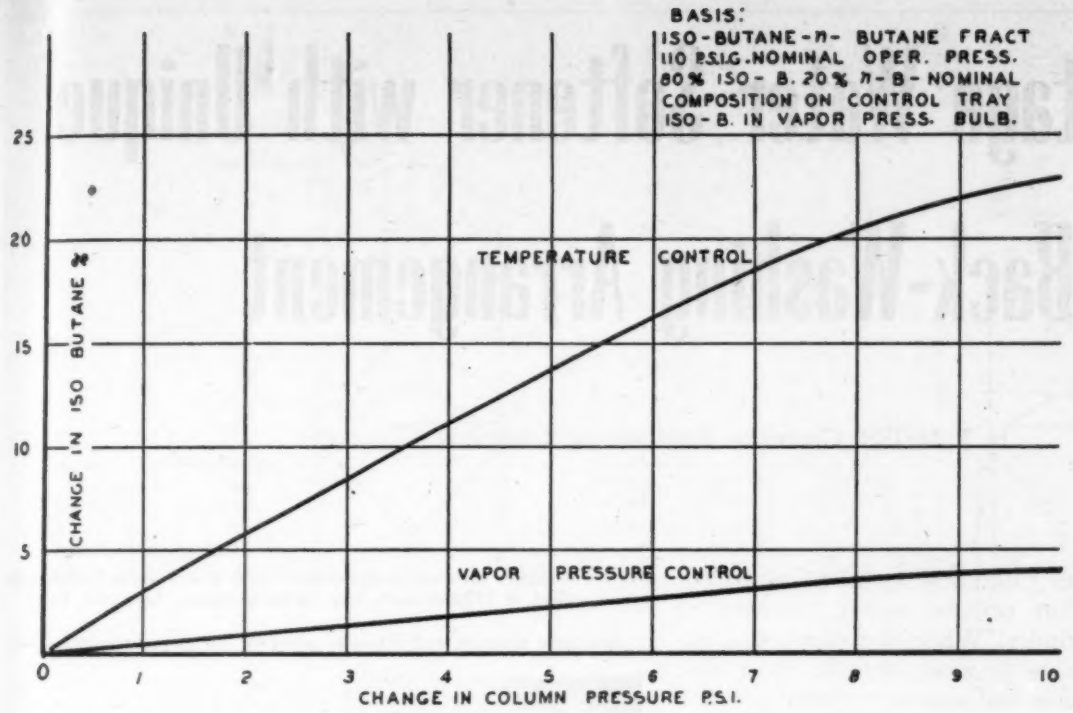


FIGURE 4 — Composition Change on Control Tray vs. Column Pressure Deviation for Binary Column Using Vapor Pressure Controller or Temperature Controller.

bulb when exposed to the column temperature will exert a vapor pressure against one side of the diaphragm or mercury U tube, the other side of which is opposed by the pressure of the column taken at the same point that the temperature sensitive bulb is located. Whenever the material at this point in the column is of the same composition of that in the bulb, no differential on the instrument will exist regardless of what pressure or temperature elevation is encountered. Conversely, by holding a zero differential pressure on the vapor pressure controller the composition on the tray will always be the same as that in the bulb.

By looking at curves on Figure 4 it can be seen that with a constant differential on the vapor pressure controller very little change in composition is encountered even with wide changes in column pressure. In other words, with a 1.0-psi. change in column pressure, the composition will only change 0.4 percent instead of the 2 to 3 percent encountered when using a temperature controller and assuming it holds the temperature perfect. Therefore, it may be said that this instrument can control composition within very close limits by controlling the differential pressure between the column and the bulb.

Although this method of control is satisfactory for binary columns, its use in columns of multi-component mixtures is somewhat limited and the limitations have not as yet been fully explored.

The petroleum and chemical industries have developed needs for new and revolutionary type instruments faster than the instrument industry was geared to keep in step. Several years after development of the need for a better means of controlling the multi-component columns, undesirable indirect methods of control are still being used because a satisfactory direct composition controller was unavailable. This is a definite challenge to the instrument industry to intensify its research and development along these lines.

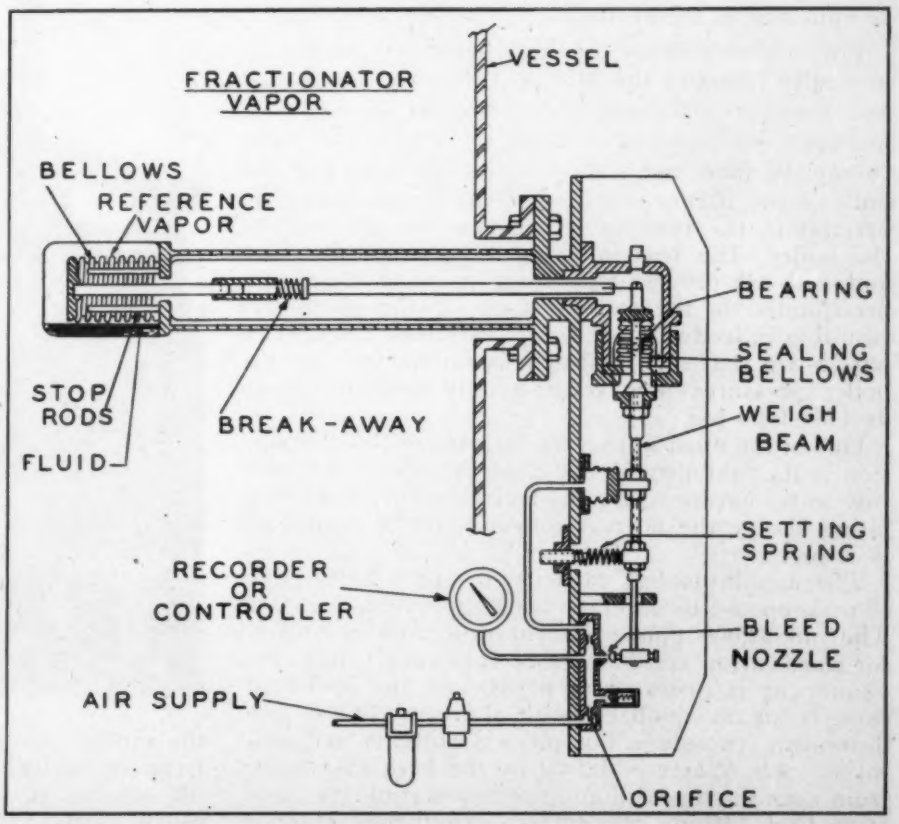


FIGURE 3—A Vapor Pressure Transmitter.

Two-Stage Water Softener with Unique Back-Washing Arrangement

H. J. MEIER, Cochrane Engineering Company, Chicago

IN 1930 The Texas Company installed a 32,000-gallon (per hour) hot process water softener at its Lockport, Ill., refinery. When the plant was expanded it was desirable to work out the most efficient treatment possible and also to reclaim as much as possible of the existing softener. The method in which the problem was ultimately solved is of considerable interest.

The new installation conditions makeup for boilers designed for 600 psi. but presently operating at 225 psi. providing pretreatment with lime and soda ash in the first stage and phosphate treatment for precipitating the remaining hardness plus deaeration in the second stage. All this is accomplished in a single sedimentation tank, the storage for the water treated with phosphate and deaerated by atomization being in an annular compartment of the sedimentation tank as indicated in the sketch.

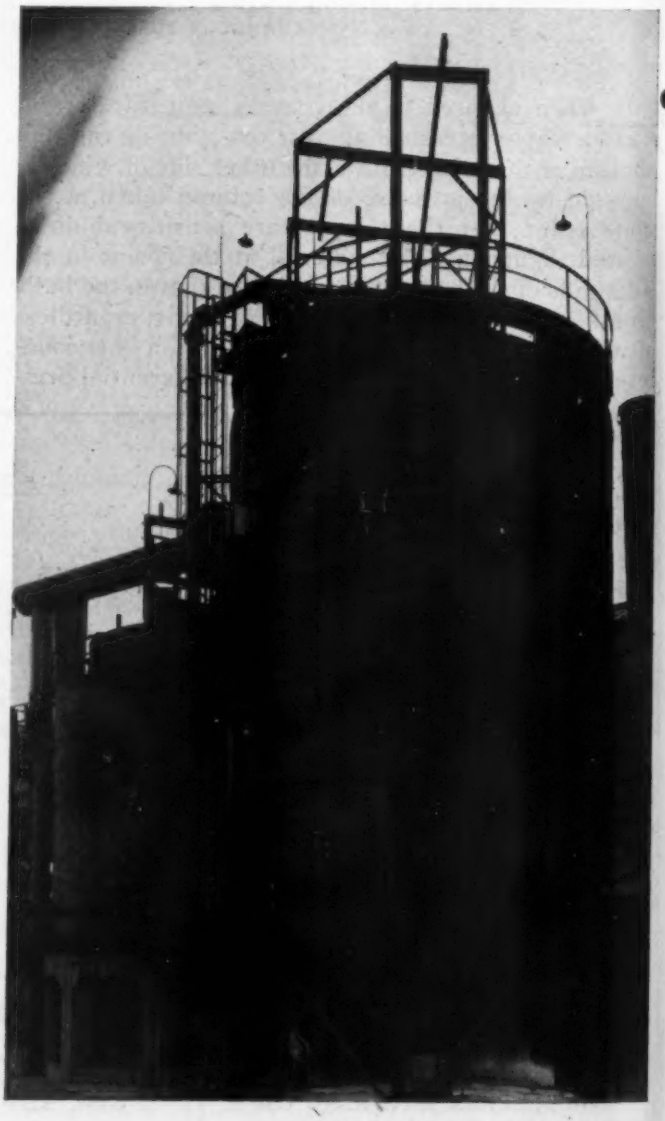
For high-carbonate or high-hardness waters as generally found in the Middle West, the Southwest and Southeast, the two-stage method of softening has been developed to combine the use of the cheap chemicals, lime and soda ash, for precipitating the bulk of the hardness with the use of phosphate to precipitate the remaining hardness, all external to the boiler. The remaining hardness from the lime and soda ash process amounting to 10 or 20 ppm. is precipitated in the second stage by the phosphate resulting in feedwater of "zero" hardness. Experience has shown that this treatment is satisfactory for the boiler pressures now commercially available, such as 1400-1500 psi.

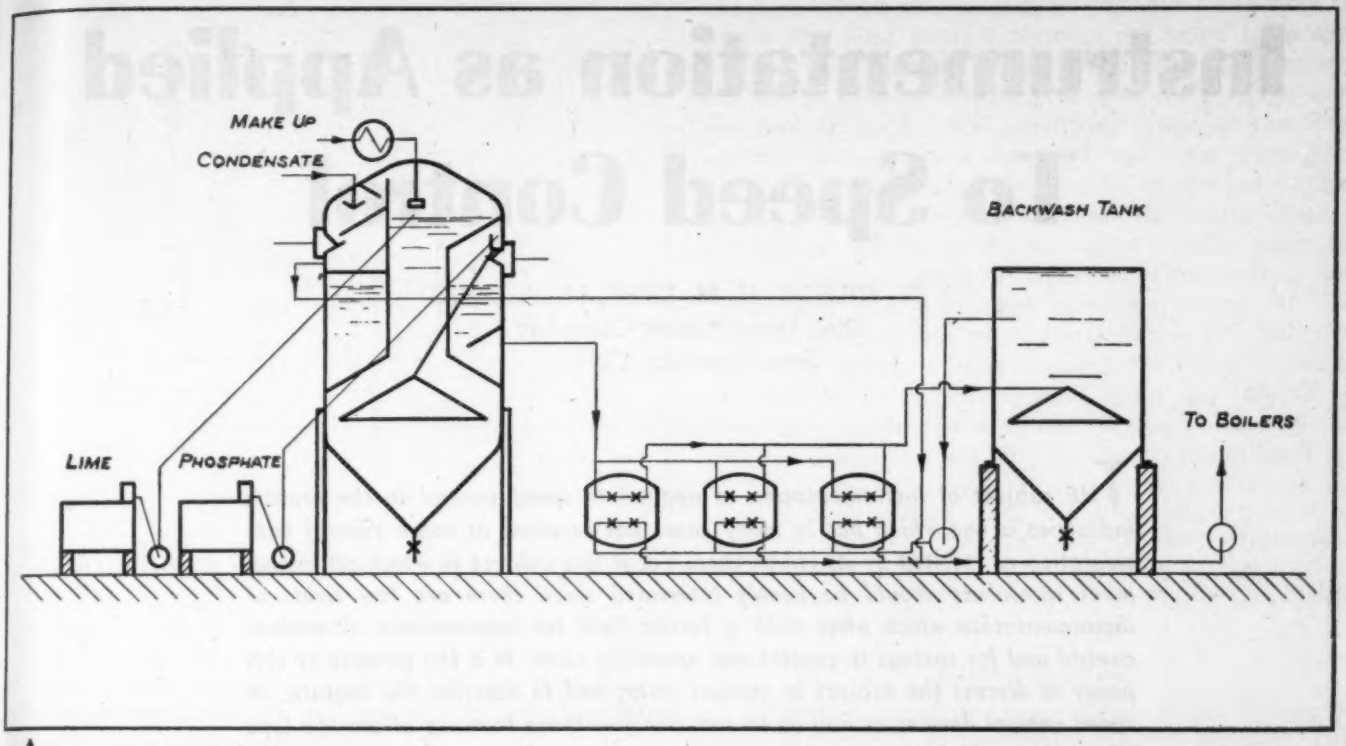
One of the most important features of this installation is its flexibility in handling the widely variable raw water hardness. By the recirculation of accumulating sludge the normal consumption of phosphate is reduced.

The apparatus has capacity to treat 70,000 gph. of makeup and to deaerate 24,000 gph. of condensate. The old 32,000 gph. sedimentation tank is utilized for clarification and storage of backwash water. The equipment is operated at 8 psi. and the backwash tank is steam-equalized with the new 70,000 gph. deaerating two-stage hot process softener sedimentation tank. Water is drawn by the backwash pump from near the top of the old sedimentation tank and, after backwashing the filters, is returned through the uptake funnel. Solids settle in the sludge cone. Between backwashing operations there is ample time for settling of the precipitates and clear water is continuously available for backwashing.

New Two-Stage Softener in Foreground with Hot Process Softener Installed in 1930 at Left. The Texas Company, Lockport, Ill.

Also note diagram and filters of plant on the page opposite. ⟶





Above—Water treatment Diagram at The Texas Company, Lockport, Illinois.

Below—The filters are arranged in two facing groups, Texaco's Lockport Works.

Instrumentation as Applied To Speed Control

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THE subject of instrumentation as applied to speed control in the process industries is one which has in many cases not received as much careful consideration as merited by its importance. Yet it is a subject in which all instrument specialists should be keenly interested since there are few fields of instrumentation which offer such a fertile field for improvement of process control and for savings in capital and operating costs. It is the purpose of this paper to discuss the subject in general terms and to describe the features of speed control devices as well as to consider how thase features affect the type of machine which they regulate.

This paper was presented at the Second Annual Short Course on "Instrumentation for the Process Industries" at A. & M. College of Texas, August 27-29, and will be published in the bulletin on proceedings of the course.

THIS paper is limited in its scope to process controls where the speed may be varied over relatively large ranges which eliminates from discussion such matters as frequency control in power generation and control of load in engines operating at substantially fixed speed such as electric motor driven compressors. The subject of motor drives is not included. Control of reciprocating gas engines, reciprocating steam engines, and steam turbines driving compressors and pumps are the principal matters with which the paper is concerned. The subject of load limit, speed limit, and overspeed trip controls are not included.

For purposes of organization the subject matter has been divided into two main classifications—Speed Controllers and Application of Speed Controllers.

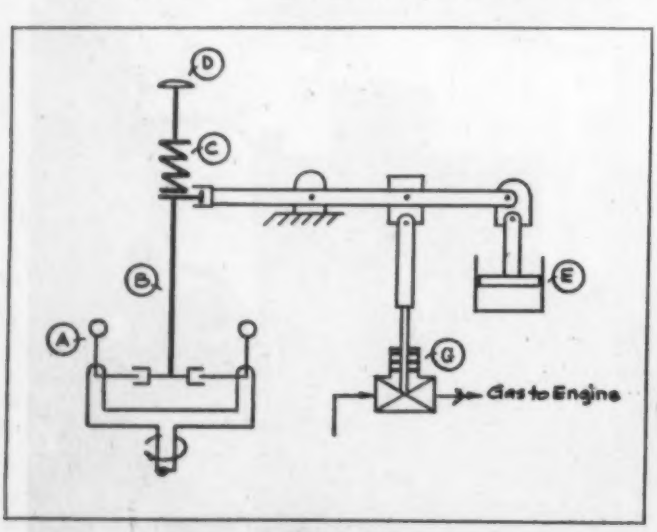

FIGURE 1
Flyball directly actuating throttle.

Speed controllers used in processes in the oil industry generally fall into types such as a flyball-actuated throttle which works against a spring, hydraulic relay governors in which a flyball positions a pilot valve which controls the flow of oil to a power piston that actuates the throttle, or a speed sensing device which actuates the flapper on an ordinary pneumatic controller which in turn modulates an air operated throttle valve. In some cases the controller proper will actuate a servo-mechanism to position mechanical parts such as automatic cut-off valves in a steam engine.

The subject of speed controllers may be classified as (1) speed controller functions, (2) speed sensing devices, and (3) a description of some representative speed controllers.

Speed Controller Functions

The functions required in a speed controller are fundamentally the same as are required by controllers for regulating flow, pressure, and temperature. In order to match the characteristics of the speed controller to that of the engine it is necessary to provide adjustments of proportional band and reset response. Rate action is generally not applied. In most speed controllers, and especially in those of the flyball type, both the proportional and reset response functions have heretofore been called "compensation" and their respective adjustments have been called compensation adjustments. In some cases a function not normally found in other process controllers may be required and that is control of the

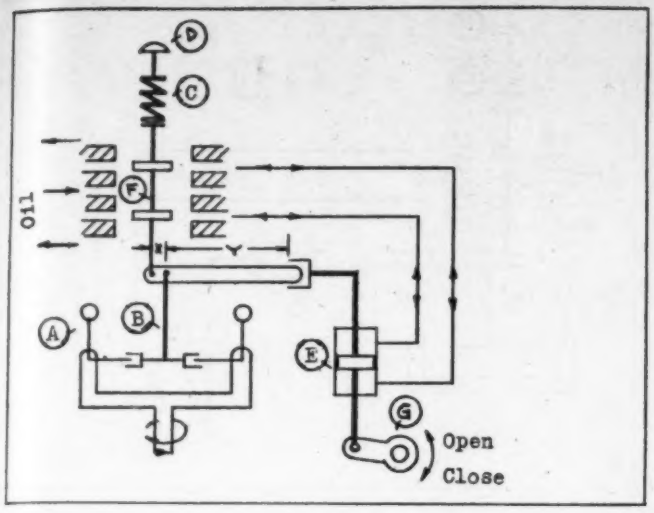

FIGURE 2
Flyball plus hydraulic servo without proportional or reset adjustments.

maximum rate of acceleration. With increase of speed of such machines as centrifugal compressors operating at speeds as high as 11,000 RPM the requirement for this function can be expected to be of greater importance in the future.

Droop Control

Another function of some speed controllers is that of droop control. Where a speed controller has no reset functions and proportional response is adjustable, speed droop is inherent as is the case in a straight proportional process controller. In other words, the speed changes with a change in load. However, once a reset device is applied there is no speed droop as the engine will be caused to return to its set speed by the reset mechanism. Now, in many cases such as electric power generation it may be desirable to have certain units carry a fixed load and to make others carry the surge or load changes. To do this it is necessary to make the fixed load machines relatively insensitive to speed change and the machines which carry the load surge very sensitive to speed change. In this manner the machines which are set to a high sensitivity will preferentially pick up the change of load as it occurs. To do this in a speed controller which has reset functions it is necessary to provide a device which will *change the speed setting* of the machine as the throttle arm moves or, in other words, to install adjustable speed droop. This is easily accomplished by providing an auxiliary arm which changes the speed setting of a controller as the throttle arm moves its position. This could be compared to a process controller in which the instrument output pressure changes the index with a change in load.

Further discussion of the above functions of controllers are limited to proportional and reset response as they are the functions normally required in speed controls in the process industries. Though it is recognized that these functions are familiar to all instrument specialists, definitions based on the hydraulic speed controls are given for purposes of completeness.

"Proportional response" or "proportional-position action" as defined for process controllers is a response which is proportional to the changes of a controlled variable. "Proportional band" is a measure of proportional response and is the range of values through which the controlled variable must vary to cause the final control element to move from one extreme to the other. Proportional band is commonly expressed in percent of controller scale range corresponding to the full operating range of the final control element. In a standard hydraulic relay governor the proportional band would be the percentage change in speed required to rotate the output control shaft from full closed to full open throttle position. For example, if the rated speed of a machine is 300 RPM and the maximum effective swing of the throttle shaft of the speed controller is 60°, and if a 120 RPM change causes the throttle shaft to rotate the full 60°, the proportional band is: $120/300 \times 100 = 40$ percent. If a 15 RPM change causes the shaft to rotate the full 60°, the proportional band is: $15/300 \times 100 = 5$ percent. Of course these figures are relative and assume that the proportional band is constant for any given setting of that adjustment which may not always be the case due to angularities of the linkages or other factors affected by the design of the speed controller.

Reset Response

"Reset Response" in a controller is either: 1) single-speed-floating, or 2) proportional-speed-floating. The single-speed-floating controller is one which produces a movement of the final control element in a direction to correct for the measurement deviation at a fixed rate so that regardless of the amount of deviation the final control element is moving at a fixed rate and will continue to do so until the measurement is returned to the control point. Most process controllers, however, employ the "proportional-speed-floating-action" which produces a movement of the final control element proportional to the measurement deviation from the control point. In speed controllers of the flyball type both types of reset response are being used. Unfortunately the reset bleed valve in hydraulic governors is not calibrated so that it is difficult to reproduce any given setting.

Despite the lack of consistent calibrations of the proportional reset adjustments a speed controller can be adjusted to match the characteristics of the engine being controlled by trial and error within a short period of time in the same manner as is done on other controllers used for temperature, pressure, or flow. It would, however, be advantageous and time saving if these adjustments were calibrated, and especially if they were labeled in units similar to those used in pneumatic controllers. The proper settings could then be computed by obtaining a reaction curve with a suitable speed recorder. It is well to state that unlike most other process controllers, speed controllers may have the additional requirement of different settings of proportional and reset response when the engine is accelerating than when it is decelerating.

Speed Sensing Devices

Speed sensing devices may be broadly classified as mechanical, electrical, and fluid (either hydraulic or gas). No attempt will be made here to describe all of these devices in detail, but it might be well to review briefly the more common types used in the process industries.

The flyball is by far the most important mechanical speed sensing device. Flyball speed sensing devices depend on a rotating shaft on which are mounted suit-

able weights which are free to pivot around the pins on which they are mounted. Motion of the weights on this shaft is opposed by a spring. The force exerted by the rotating weights causes compression of the spring which restrains their motion. This displacement is calibrated against the speed of the rotating shaft and is roughly a function of the square of the speed. The output motion is used to actuate a suitable servo-mechanism which controls the throttle of the machine. There are other types which are used but which are not covered in this paper due to the infrequency of their use in the process industries.

Electrical speed sensing devices include the drag cup, tachometer generator, and impedance bridge types.

The drag cup type of electric tachometer is the unit which has probably found widest application in industry. In spite of its wide application, however, it is seldom used for speed governing or control applications.

The elements of the drag cup tachometer include the cylindrical drag cup mounted on pivots so that it is free to rotate axially, an Alnico armature which is rotated by the machine whose speed is being measured, a calibrated spring assembly which measures the torque produced by the drag cup, and finally a mechanism linkage to transmit (the speed related motion) to an indicating pointer or mechanism.

In operation, the armature is rotated at a speed equal or proportional to that of the machine. In so doing the magnetic field of the armature is rotated about the axis of the drag cup inducing a current in the drag cup which is proportional to the rotational velocity of the armature. The flow of current in the drag cup establishes another magnetic field which reacts with the field of the armature tending to cause the drag cup to rotate in the same direction as the armature. The force tending to cause the drag cup to rotate is opposed by the force of a spiral spring, the movement of which is calibrated in terms of speed.

Tachometer generator units are quite widely used in industry for indicating and recording speed instruments. Where relatively high precision speed control is required with electric governor systems, this type of speed sensing mechanism has been found to be very satisfactory. For such service both alternating and direct current tachometer generators are used, about the only difference being that the d-c unit has a commutator for converting the current generated to direct current while the a-c unit generally employs some type of rectifier. The indicating or recording element is generally a voltmeter calibrated in units of speed.

Impedance Bridge Type

The impedance bridge type of speed or frequency measuring system generally consists of an electronically or mechanically balanced bridge circuit. The measuring circuit employed in such equipment usually consists of a frequency sensitive bridge composed of parallel resonant and series resonant arms. Units of this type are used where highly precise speed governing is required in such applications as in power generating plants where precise frequency control must be maintained.

One of the most common forms of fluid (hydraulic) speed sensing device is the hydraulic differential pressure type. It consists of an oil reservoir, a positive displacement gear pump, and an adjustable resistance. The pump takes suction from the reservoir

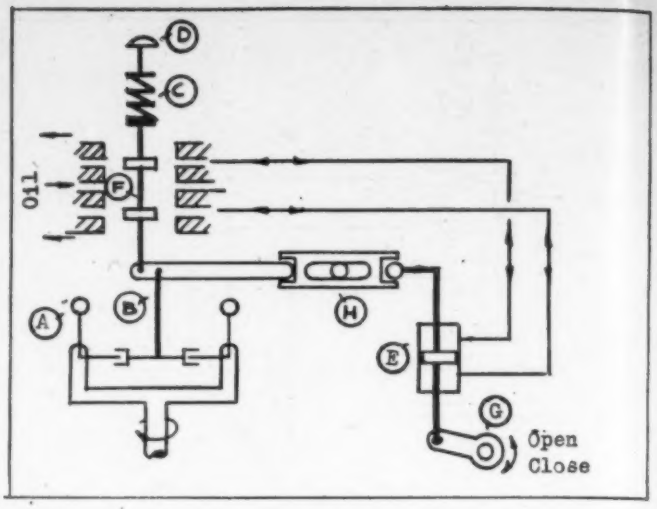

FIGURE 3

Flyball plus hydraulic servo with proportional adjustment. No reset.

and discharges through the adjustable restriction back to the reservoir. Since the positive displacement pump is driven directly by the engine the amount of oil pumped is a function of the speed. The discharge pressure is a function of the pressure drop through the restriction. A bourdon tube pressure element may then be used to measure the pressure and can be calibrated against the speed for a given setting of the needle valve, or adjustable orifice, which provides the resistance to the flow of oil. The calibration is of course affected by the viscosity and specific gravity of the oil which may vary due to change in temperature and pressure. In addition, the calibration is affected by wear. However, once the system has reached an equilibrium temperature the calibration can be held within close limits. The dead spot or hysteresis of this device is extremely small. The pressure of the metering element increases as the square of the speed so that a straight line characteristic of speed versus pressure is not achieved.

Centrifugal Pressure Indicators Included

The classification of fluid devices also includes centrifugal pressure indicators which consist of centrifugal pressure generators which take suction from an oil sump and whose discharge is connected to a pressure measuring element. The only flow of oil involved is that required to cause motion of the bellows or bourdon which measures the output pressure. The output pressure of these devices vary as the square of the speed and consequently do not have a straight line characteristic. The output pressure is not affected by changes in viscosity or by efficiency of the pump. It is affected, however, by changes in density of the oil but temperature changes have only a small effect on the calibration of the device. The dead spot or hysteresis of the system is very small and within the limits required for process control.

Similar systems have been used where a small centrifugal air blower is used in place of the oil pressure generator. The oil system has the advantage of using a fluid of high density where reasonably high pressure ranges can be used.

By far the most generally accepted sensing mechanism found on speed controllers used on machines in the process industry is the flyball type although there are indications that electrical sensing systems will find increasing use due to the ease with which they

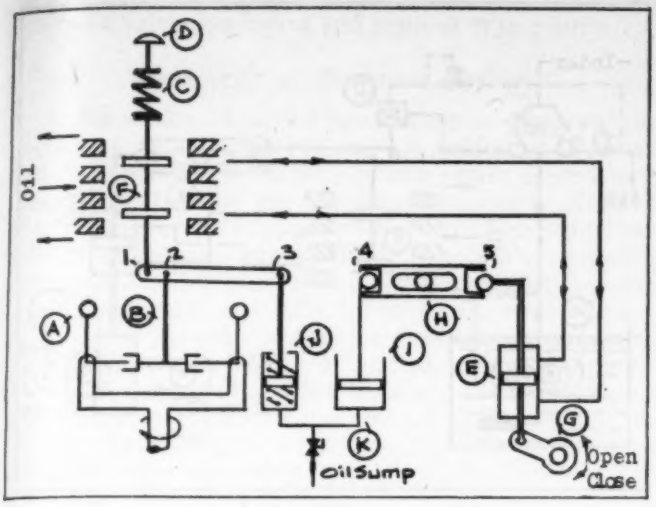

FIGURE 4

Flyball plus hydraulic servo with proportional and reset adjustments.

can be connected to electronic servo-mechanisms. Whatever system is used it is necessary that the speed indication be accomplished with the lease possible lag since in engines the lag of the speed controller may often be the greatest lag in the system. The lag inherent to pneumatic instruments similar to those used for control of flow, pressure, and temperature may often be entirely too great to provide proper control of engines such as turbines.

Description of Some Speed Governors

It is proposed now to describe some of the available speed controllers which are in general use and to emphasize the similarity that exists between the functions of speed control devices and the process instrument controllers with which the process instrument specialist is generally so much more familiar. The description will cover various types of speed sensing devices as applied to several servo-mechanisms in which are incorporated some of the control functions discussed previously.

1) *Flyball Directly Actuating the Throttle*

Figure 1 shows a diagrammatic sketch of a speed controller in which the flyballs are designed with sufficient weight to provide the power required to directly actuate the throttle of an engine.

On an increase in speed, flyballs *A* move outward causing stem *B* to move upward against spring *C*. This causes stem of valve *G* to move downward and close the throttle. Dashpot *E* may be installed to dampen cycling. Regulation of speed is obtained by changing the compression in spring *C* either by a hand wheel and screw or through air diaphragm *D*.

For a fixed spring tension this speed controller has a fixed throttle position for each speed. The force exerted by the flyball must be great enough to make friction losses a small proportion of the total force exerted by the weights in order to reduce the dead spot or hysteresis to a satisfactory minimum. Ball and needle bearings are often used on all journals. The friction at the stuffing box of valve *G* must be low.

2. *Flyball Plus Hydraulic Servo Without Proportional or Reset Response Adjustments*

Figure 2 shows a flyball speed controller with a hydraulic relay in which the flyball controls a pilot valve which controls the oil flow to a hydraulic piston. This in turn actuates the throttle shaft.

An increase in speed makes weights on *A* move outward which moves stem *B* upward which in turn moves pilot valve *F* upward. This admits oil pressure to the bottom of cylinder *E* and exhausts oil from the top of the cylinder. Shaft *G* turns clockwise the throttle. Pilot valve *F* is restored to neutral by the upward movement of the piston. The proportional band is a function of the length of arms *X* and *Y*.

This speed controller has the same characteristics as that shown in Figure 1 with the exception that the servo-mechanism reduces the hysteresis due to friction. The flyballs only have to overcome the friction in the pilot valve. In practice the pilot valve or the valve sleeve is made to rotate at governor speed which reduces the hysteresis caused by this frictional resistance. Dead spot as affected by pilot valve friction at rated speed can be reduced to less than 0.1 percent.

3. *Flyball with Hydraulic Servo Plus Proportional Band Adjustment*

Figure 3 shows a flyball speed controller with a hydraulic servo-mechanism. The flyball controls a pilot valve which controls the oil flow to a hydraulic power piston which in turn actuates the throttle shaft. The power piston restores the neutral position of the pilot valve through an adjustable link and the adjustment of this link provides the proportional band adjustment as described below.

An increase in speed makes weights on *A* move outward which moves stem *B* upward which in turn moves pilot valve *F* upward. This admits oil pressure to the top of cylinder *E* and exhausts oil from the bottom of the cylinder. Shaft *G* turns counterclockwise closing the throttle. Pilot valve *F* is restored to neutral by the downward movement of the piston acting through the adjustable link *H*. The pin in *H* can be moved, thus changing the magnitude of feedback to the pilot valve as compared with the movement of power piston *E*. Thus a change in the position of the pin in *H* changes the range of values through which the controlled variable (speed) must vary to cause the final control element (throttle shaft) to move from full open to full closed position.

This speed controller has the same characteristics as that shown on Figure 2 with the exception that an adjustment has been provided for changing the proportional band.

4. *Flyball Plus Hydraulic Servo with Proportional Band and Reset Adjustments*

Figure 4 shows a flyball speed controller with a hydraulic relay in which the flyball controls a pilot valve. This controls the oil flow to a hydraulic power piston which in turn actuates the throttle shaft. However, instead of restoring the pilot valve to its neutral position directly through an adjustable link, the link moves a system of two hydraulic pistons between which a bleed is incorporated. This bleed provides a reset response in much the same manner as in a pneumatic instrument. A description of the action of the reset device is given below.

An increase in speed makes weights *A* move outward which moves stem *B* upward which in turn moves pilot valve *F* upward. This admits oil pressure to the bottom side of power piston *E* and exhausts oil from the top of the cylinder. Shaft *G* turns clockwise closing the throttle. Pilot valve *F* is restored to its neutral position by a power piston stem which moves point *5* upward and point *4* downward through the adjustable link *H* which provides proportional band adjustment. When point *4* moves downward oil is pumped from cylinder *I* to cylin-

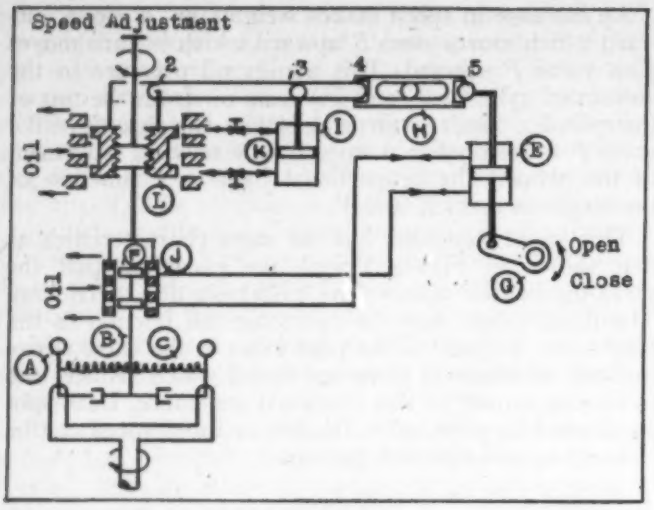

FIGURE 5

Flyball plus hydraulic servo with proportional and reset adjustments.

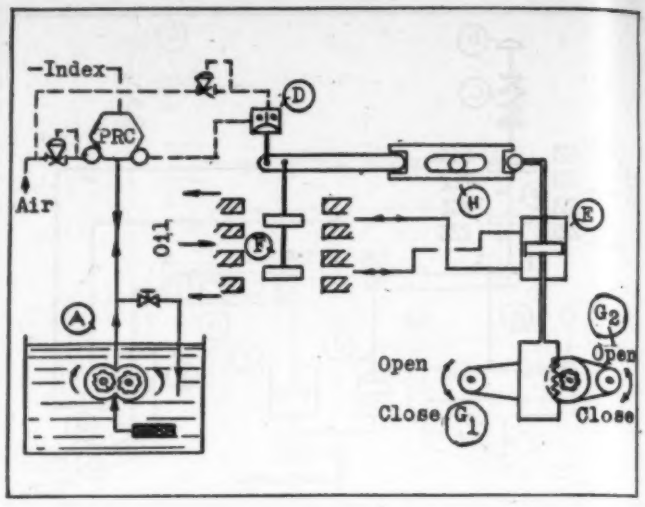

FIGURE 6

Oil pressure plus PRC plus hydraulic servo with proportional and reset adjustments.

der *J* and point *3* moves upward causing point *1* to move downward to its neutral position. The reset function comes into play as oil bleeds off through needle valve *K*. The piston in cylinder *J* moves to its center position under influence of the springs in that cylinder. With point *3* and point *1* in their neutral positions, point *2* must be in its original position and constant speed is maintained regardless of load or throttle position. This type of speed controller is termed an isochronous governor. If required, a predetermined amount of speed droop may be added, changing the spring tension on spring *C* by means of a cam actuated by the power piston.

Another Type Controller

In some speed controllers the feedback of the power piston moves the pilot valve sleeve which in turn exposes another pilot valve which regulates a separate power piston controlling the reset function. This type of controller is shown in Figure 5. An increase in speed makes weights *A* move outward which moves stem *B* upward which in turn moves pilot valve *F* upward. This admits oil pressure to the bottom side of power piston *E* and exhausts oil from the top of the cylinder. Shaft *G* turns clockwise closing the throttle. In this controller the flow of oil to the power cylinder is stopped by bringing the sleeve *J* which contains the pilot valve ports up to a position where the ports are closed. This is done when the power piston stem moves point *5* upward and point *4* down and through the adjustable link *H* which provides proportional band adjustment. When point *4* moves downward point *2* moves upward, thus raising the auxiliary pilot valve *L* and sleeve *J*. The reset function comes into play when pilot valve *L* is moved upward uncovering the ports leading to the auxiliary power piston *I*. Oil flows into the top of piston *I* and is exhausted from the bottom. This moves piston *I* and point *3* downward. Hence point *2*, pilot valve *L*, and sleeve *S* are moved slowly downward which allows a small bleed into the bottom of the power piston *E*. Power piston *E* will continue to move until the throttle has been closed enough to reduce the speed and bring the flyballs *A* and hence pilot valve *F* into their original positions at which time the auxiliary pilot valve *L* and pilot valve *F* will be in neutral positions and the flow of oil to both cylinders will stop. The reset response is adjusted by means of timing valves *K* which vary the rate of oil flow to piston *I*. Speed setting is accomplished by turning the control shaft which fixes the distance between pilot valve *L* and pilot sleeve *J*. Hydraulic pilot valve *F* is shown as a double shoulder type. Some speed controllers use a single shoulder type which controls the oil pressure to one side of the power piston *E*. The opposite side of the piston has a fixed oil pressure or is spring loaded.

It is well to add that many speed controllers provide adjustable reset response without the adjustable link which eliminates the feature of adjustable proportional band.

5. *Oil Pressure Plus Pressure Instrument Plus Hydraulic Servo With Proportional Band and Reset Adjustments*

Figure 6 shows a speed controller for automatic cut-off regulation of a steam engine. A positive displacement pump takes suction from an oil sump and discharges back to the sump through a needle valve. With a fixed position of the needle valve the output pressure of the pump is a function of the speed. This pressure is connected to a pressure recorder controller which is equipped with proportional band and reset adjustments. The output air pressure from the controller is applied to an air diaphragm which is equipped with a positioner. The air diaphragm moves the hydraulic pilot valve. The pilot valve controls the flow of oil under pressure to the power cylinder which moves the cut-off valve through a rack gear and chain or gears. Adjustable feedback to restore the neutral position of the hydraulic pilot valve is provided through suitable linkage. It is advisable to have adjustable proportional band so that the proper working range of the pressure recorder controller may be maintained. A centrifugal pump operating at shut-off head could also be used as an alternative speed sensing device.

An increase in speed increases the output pressure of pump *A* and causes the PRC to operate air motor *D* (which is selected so that air failure shuts down the engine). Since it is desired to close the throttle on increase of speed, the pneumatic system is arranged so that increase of pressure at pump *A* will cause hydraulic pilot valve *F* to move upward. This admits oil to the bottom of power cylinder *E* and exhausts oil from the top of the cylinder thus causing the power piston and rack to move upward turning the sprockets in a clockwise direction and reducing the steam cut-off point of

the engine. Power piston *E* also causes link *H* to move the pilot valve downward and restores it to neutral.

Hysteresis of Governor Systems

A discussion of speed controllers is certainly not complete unless there is some discussion of the over-all dead band or hysteresis of the entire control system. This probably can best be illustrated by describing the hysteresis encountered in two control systems where actual data are available. The first is a flyball speed controller plus hydraulic servo with proportional and reset response adjustments controlling a gas engine driven compressor similar to the control system shown on Figure 5. The second is an oil pressure speed controller plus pressure instrument plus hydraulic servo with proportional and reset adjustments controlling an automatic cut-off steam engine similar to the control system shown in Figure 6.

1. *Gas Engine Driven Compressor*

In this case data were taken under full torque load from which a plot of engine speed versus input pressure to the diaphragm control valve could be made. This plot is shown on Figure 7. As is seen, the hysteresis is not severe but is considerably greater in magnitude than is considered satisfactory for precision control. An investigation was made to determine the distribution of the hysteresis and this is shown in Figure 8. It will be noted that a large percentage of the hysteresis is encountered in the mechanism which sets the speed of the controller and that by improving the precision of this part of the system quality control can be secured. It brings out the fact that the speed controller was designed for speed control where the dead spot of the manual speed setting mechanism is of little importance and that no further research was done to determine its applicability to process controls where speed setting varies over a relatively large range. The difficult job of reducing hysteresis in the flyballs and hydraulic pilot valve has been adequately consummated. The easy job of reducing hysteresis in the speed setting mechanism was neglected.

2. *Automatic Cut-off Steam Engine*

In this case data were taken under full load from which a plot of engine speed versus input pressure to the diaphragm could be made. This plot is shown on Figure 9. It will be noted that hysteresis is so severe that the control system cannot be considered to be operative. Many installations with this system of control have been taken off automatic control and placed on hand control because of the poor characteristics of the speed controller. An investigation disclosed that a precise valve positioner was required on the diaphragm motor and that the design of the hydraulic pilot valve on the servo-mechanism had to be changed to avoid overlap with the corresponding parts in the valve sleeve. Figure 10 shows the response of the control system after the change was made. Since no adjustment of the proportional band was provided it was impossible to flatten the curve to suit the working range of the pressure instrument, but satisfactory performance was secured.

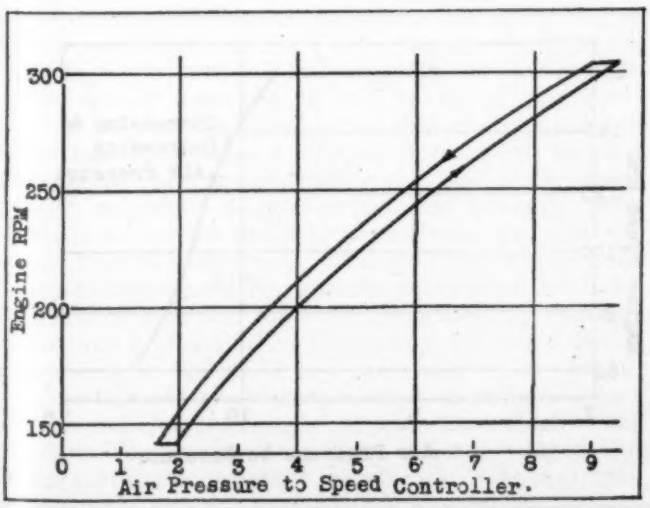

FIGURE 7
Over-all hysteresis gas engine driven compressor.

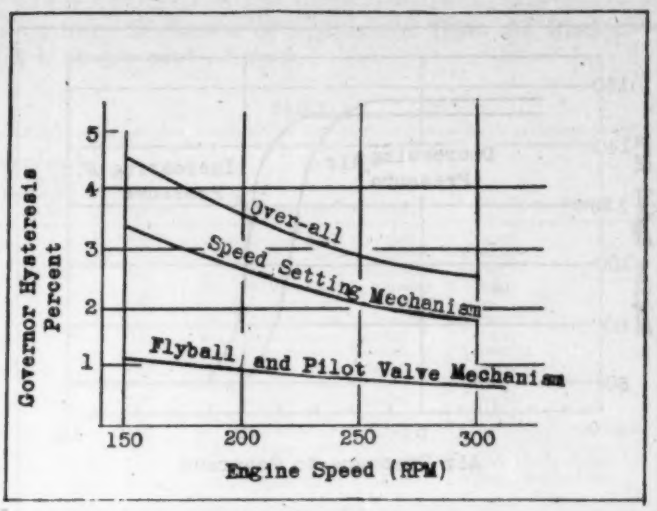

FIGURE 8
Distribution of hysteresis gas engine driven compressor.

In the above discussion, data have been given with reference to the functions required in a speed controller and the types of speed sensing devices which are used in process industries. In addition there are presented diagrammatic sketches of speed controllers along with a discussion of their operation. There is also described the importance of keeping hysteresis to a minimum in speed controllers. In the second part of this paper a discussion will be given of the application of speed controllers to various engines.

Application of Speed Controllers

The application of speed controllers to engines is affected by many factors that do not depend on the speed controller itself. There are characteristics of the engine such as its inertia and ability to pick up loads which are important. Some engines will stall easily or may require precision control to avoid hunting with its attendant peak loads. Other engines will not carry a power overload for even short periods if the overload is a torque overload. They will, however, satisfactorily carry an overload if the torque remains normal and the speed of the engine is increased. Still other engines have load characteristics which are very sensitive to speed and special precaution should be taken to prevent speed change especially if the change affects other instrumentation. Cycling in one controller may easily upset the control of the entire process.

Another important factor to be closely studied in any application of a speed controller is the magnitude

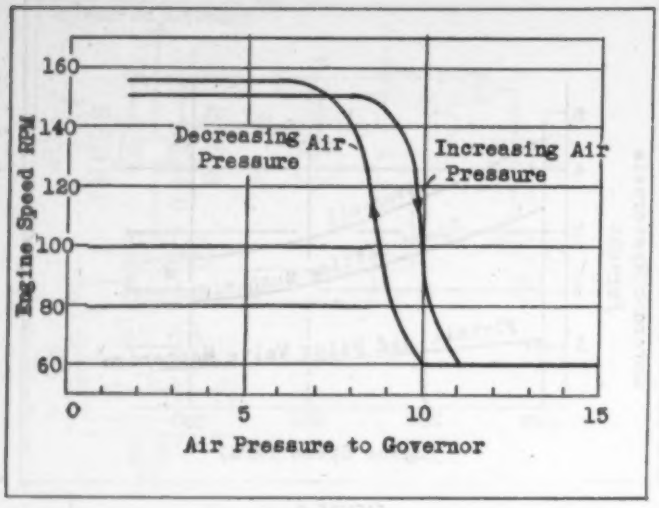

FIGURE 9

Hysteresis automatic cutoff steam enigne before redesign.

of the load change which is to be expected during the most adverse operating circumstances. In this, however, the process industries are fortunate since the magnitude of load change is relatively small, and control relatively simple, compared to that experienced with rockets, aircraft turbo superchargers, and ordnance aiming devices. If properly applied standard instruments and speed controllers have a wide enough range of adjustments and respond quickly enough to provide adequate speed control in most processes. However, to date, the lack of knowledge both as to the proper application of a controller to a plant and adjustments within the speed controller itself have made the speed controller a constant source of irritation to industrial process operators.

Compressors operating at low suction pressure can easily be overloaded in torque if the suction pressure becomes higher than design; the lower the design pressure the more serious an increase becomes. For example, a compressor is designed for 15 psia suction pressure and 300 psia discharge. The suction pressure rises to 20 psia slightly reducing the compression ratio. However, the *weight* of gas entering the compressor per stroke is increased by one-third which overloads the engine by almost the same amount. Since the engine cannot carry an appreciable torque overload, the machine will stall.

Poor application of speed controls is not only liable to cause inordinately high operating costs but also may lead to higher investment costs. For example, if a compressor installation is provided with eleven 1000 HP compressors and one compressor could be eliminated by proper selection of controls, a capital investment saving of nearly a quarter of a million dollars might be secured.

Assuming a gas engine driven compressor installation which is broken up as follows:

Normal BHP Required	9,000
Additional BHP due to surge	1,000
Total Requirements	10,000
Normal RPM	300
Maximum RPM	350
Increase in available HP for short periods	50/300 = 16.7%

One spare machine provided for maintenance purposes.

If control is not good it is necessary to provide eleven 1000 HP compressors. With precision control ten machines could be installed. Nine machines could carry the surge load due to the fact that it occurs only infrequently and for short periods of time. In some installations where precision control is not provided it may be necessary to install even more compressors rating them at 80 or 85 percent their normal horsepower to avoid stalling of a machine which may cause the complete compressor installation to quit.

The application of speed controllers is discussed below only with reference to gas engine driven reciprocating compressors, steam engine driven reciprocating compressors, and steam turbines.

Gas Engine Driven Reciprocating Compressors

Proper speed control of gas engine driven compressors may be accomplished in several ways depending on the service requirements. Where load changes are of small magnitude and occur gradually a simple speed controller consisting of flyballs mechanically actuating the throttle may be used. Change of speed is accomplished by setting the spring tension by hand or by pneumatic means. For example in a gasoline absorption plant where the load is steady and the gathering lines are of large capacity, a pressure change at the suction takes place slowly. The operator has ample time to hand set the spring tension on the speed controller. A refinement would be to utilize a pressure instrument on the suction which would pneumatically set the spring controllers of all engines. If the pressure controller is equipped with proportional and reset adjustments very good control can be obtained provided that hysteresis does not exist in the control system to any appreciable extent. One fourth percent hysteresis at normal load can be considered as good control. Failure of an engine is the most serious upset which might occur. In that case the suction pressure would tend to build up and the pressure controller would increase the speed of the other machines. On gradual load changes this is satisfactory.

Now consider the case of a battery of gas engine driven compressors on a refinery gas plant. The change in load can be sudden. The system considered above has some disadvantages since without index setting of the speed controllers by the pressure controller the engine must slow down to open the throttle. The pressure controller has to correct for load

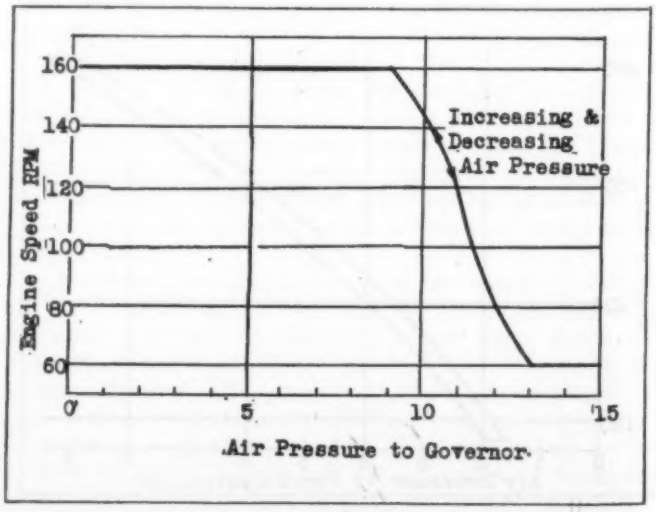

FIGURE 10

Hysteresis automatic cutoff steam engine after redesign.

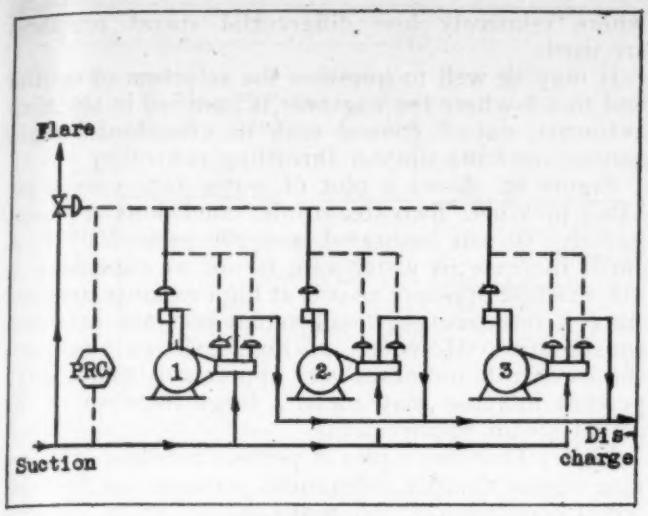

FIGURE 11
Full range load control gas engine driven compressor.

change as well as for the droop of the speed controller. Better results can be achieved if an isochronous governor is mounted on the engine which will hold the speed regardless of load until the index or set point is changed by the pressure controller. By properly adjusting the proportional and reset response of the speed controller the engine can be stabilized within its own control system and the pressure controller can be set for the other process conditions.

Next consider a gas engine driven compressor where it has been necessary to reduce capacity to a figure which is below the stalling speed of the compressor. Assume that automatic valve lifters are used to unload one side of the cylinders at a time in steps. Assume also that the engine is running at 300 RPM when the load is increased from half load to full load by the valve lifters. With a direct actuated flyball governor the sudden increase in load would cause the engine to slow down in order to open the throttle *at the very time that maximum power is required.* This operation can and does stall the engine. At best it limits the rating at which an engine can be operated. An isochronous speed controller would hold the RPM at 300 regardless of load. Index set of the isochronous speed controller could be used. Complete instrumentation of the installation as shown in Figure 11 consists of a master suction pressure controller with proportional and reset adjustments. On decrease of suction pressure the output pressure of this controller would first reduce the speed of the compressors to the minimum speed that the compressor limits have been set. A further decrease in suction pressure would start unloading one end of the compressor cylinders progressively, and perhaps then continue to unload the other cylinder ends until the installation is completely unloaded. Increase in suction pressure would reverse the procedure until the installation is at full load. Surges above the normal load would be handled by increasing the speed of the engines above 300 RPM to a maximum of 350 RPM. In some cases it would be advisable to include a further control element consisting of a value which vents gas from the suction to a flare if loads exceed the capacity of the compressor installation. Although this arrangement extends automatic operation beyond the limits which are normally necessary, it does indicate what can be done in making all these operations fully automatic. Sequence of operations from no load to full load are given below.

TABLE 1

Instrument Output Pressure psig	RPM Engines	Progressive Loading	Vent to Flare
0	250	All Cylinder Ends Unloaded	Closed
1	250	All Cylinder Ends Unloaded	Closed
2	250	All Cylinder Ends Unloaded	Closed
3	250	No. 1 Compressor ½ Loaded	Closed
4	250	No. 2 Compressor ½ Loaded	Closed
5	250	No. 3 Compressor ½ Loaded	Closed
6	250	No. 1 Compressor Loaded	Closed
7	250	No. 2 Compressor Loaded	Closed
8	250	All Cylinder Ends Loaded	Closed
9	275	All Cylinder Ends Loaded	Closed
10	300	All Cylinder Ends Loaded	Closed
11	325	All Cylinder Ends Loaded	Closed
12	350	All Cylinder Ends Loaded	Valve Begins to Open
13	350	All Cylinder Ends Loaded	Valve 50% Open
14	350	All Cylinder Ends Loaded	Valve 100% Open
15	350	All Cylinder Ends Loaded	Valve 100% Open

Due to the reset action of the master pressure controller all the above operations can take place without appreciable change of the suction pressure.

On most installations speed control plus manual unloading of the compressor ends is satisfactory. Adjustable clearance pockets may be used in place of unloaders and have the advantage of modulating the capacity instead of the on-off control afforded by valve lifters.

Some gas engine installations have been arranged in such a manner that the base load is carried by several machines whose speed is fixed. Fluctuations are carried by one or more machines on speed control. The purpose of this arrangement is to operate the base load machines at maximum efficiency, thus saving in fuel costs. The disadvantage is that the fixed speed machines are not available for peak surge loads and consequently a greater number of machines must be installed. It is believed that the additional cost of fuel entailed where all engines are used to carry surge loads is of small magnitude where fuel gas cost is reasonably low and that it would be very difficult to justify the additional capital required for installation of additional machines.

Gasoline and diesel engines have operating characteristics which are similar to those which apply to gas engines, with the exception that they do not stall as easily. This is partly due to the better control of air fuel ratio and partly to better ignition characteristics. It is the authors' opinion that considerable

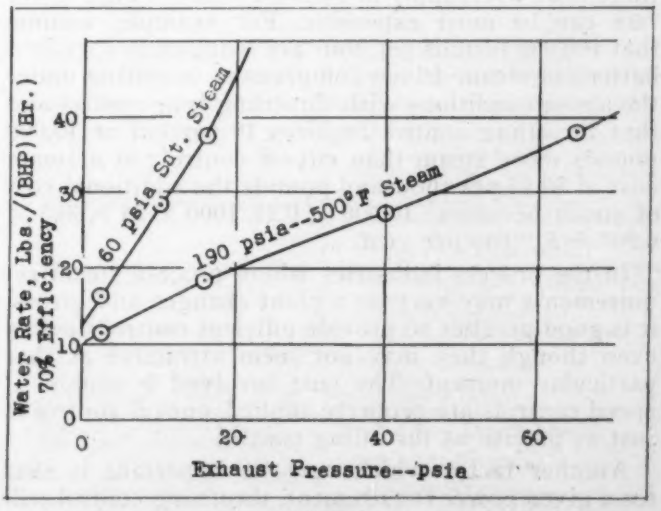

FIGURE 12
Effect of exhaust pressure on water rate.

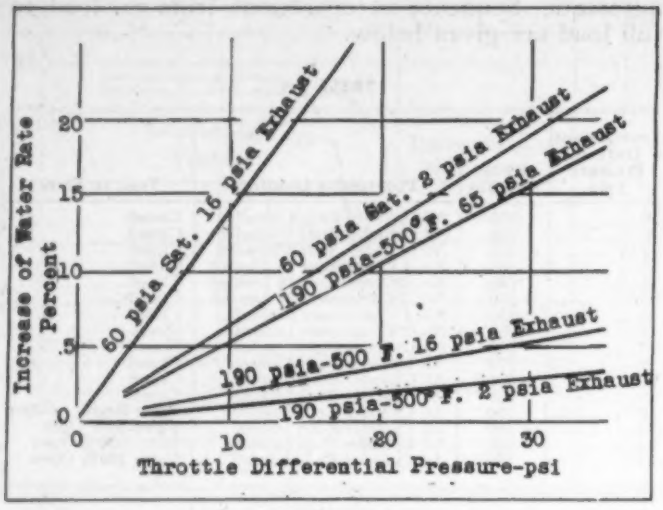

FIGURE 13
Effect of throttling on water rate.

improvement can be made on the control of the air to fuel ratio on at least some of the gas engines now being marketed.

Steam Engine Driven Reciprocating Compressors

Speed control of reciprocating steam engines probably is as old a control problem as exists. It is interesting to find that its application is not as well understood as it should be, even though it is acknowledged that connecting the speed control to a process controller does add certain complications.

Two types of controls are generally used. The simplest is the throttling type which throttles the steam to the engine. The second is the cut-off type which has advantages of economy in steam usage. Often both are used, in that cut-off is set manually and automatic control is accomplished by throttling. Automatic cut-off control can be made just as precise as throttling control if it is properly designed and applied.

If a steam engine is operating with steam at 190 psia—500° F. and exhausing at 65 psia and there is a large requirement for process steam at that exhaust pressure, a requirement even larger than the exhaust steam produced by the engine, it is obviously ridiculous to consider the water rate as critical. However, if there is an oversupply of exhaust steam, a high water rate can be most expensive. For example, assume that 100,000 pounds per hour are required to operate a battery of steam-driven compressors operating under the above conditions with throttling type control and that throttling control requires 10 percent or 10,000 pounds more steam than cut-off control; at a steam cost of $0.25 per thousand pounds the additional cost of steam becomes: $10{,}000 \times 0.25/1000 \times 24 \times 365 \times 0.90^* = \$19{,}600$ per year.

In the process industries where process steam requirements may vary as a plant changes and grows, it is good practice to provide efficient control devices even though they may not seem attractive at that particular moment. The cost involved is minor. If speed controls are properly applied, cut-off control is just as precise as throttling control.

Another factor which may be important is that for a given power requirement, throttling control will require larger cylinders. This becomes of importance where relatively low differential steam pressures are used.

It may be well to question the selection of control and to see where the engineer is justified in selecting automatic cut-off control with its attendant complications over the simpler throttling controller.

Figure 12 shows a plot of water rate versus exhaust pressure. Two steam inlet conditions are used, namely: 60 psia saturated, and 190 psia—500° F. A small increase in water rate is not as expensive at low exhaust pressure as it is at high exhaust pressure since it represents a small actual increase in steam consumption. However, at high exhaust pressures the water rate increases very appreciably and a small percent increase may mean a large increase in the actual steam requirements.

Figure 13 shows a plot of percent increase of water rate versus throttle differential pressure for five different conditions of live and exhaust steam. Experience shows that with close supervision of the operators to make sure that they set the manual cut-off frequently the following throttle differential pressures can be considered to be the lowest that can be obtained:

TABLE 2

STEAM CONDITIONS	Throttle Diff.	Water Rate Non-throttling	Water Rate Percent Increase	Water Rate Throttling
60 psia sat ⟶ 16 psia Exhaust	10	37.5	14.0	42.7
60 psia sat ⟶ 2 psia Exhaust	10	16.3	6.5	17.4
190 psia 500° F ⟶ 65 psia Exhaust	20	38.0	10.5	41.9
190 psia 500° F ⟶ 16 psia Exhaust	20	18.4	3.5	19.1
190 psia 500° F ⟶ 2 psia Exhaust	20	11.3	2.0	11.5

If close supervision is not maintained in order to secure proper setting of the manually operated cut-off, the throttle valve differential may be considerably higher and the water rate will increase. It may be argued that it is not possible to operate above the design differential due to the fact that the machine will not have sufficient power to carry the full load. However, in selecting a compressor for a given load it is not usually possible to match the load exactly to the nearest standard machine. It is necessary to select the next larger size. This factor, in addition to arbitrary safety factors made to allow for decrease in volumetric efficiency due to wear, and greater pressure drop in the steam supply lines than is encountered in operation, often means that a machine is installed which is larger than required by actual operating conditions and can therefore be operated above the designed pressure differential.

It is not well to leave this subject before cautioning users with reference to mechanical difficulties which may be encountered with automatic cut-off control. The design of the device should be such that it does not interfere with barring over the flywheel, and it should have safeguards to prevent the gears or chains from slipping. In one installation a slippage of this type caused the steam valve to overtravel and ended up by wrecking the eccentric rods and straps. A positive stop on the screw which sets the valve position is a desirable feature. If such precautions are taken, improper maintenance or setting of the device cannot do serious damage.

Steam Turbines

Speed controllers for steam turbines throttle the steam supply to the turbine. If it is expected that the machine driven by the turbine may be required to

* Stream time factor.

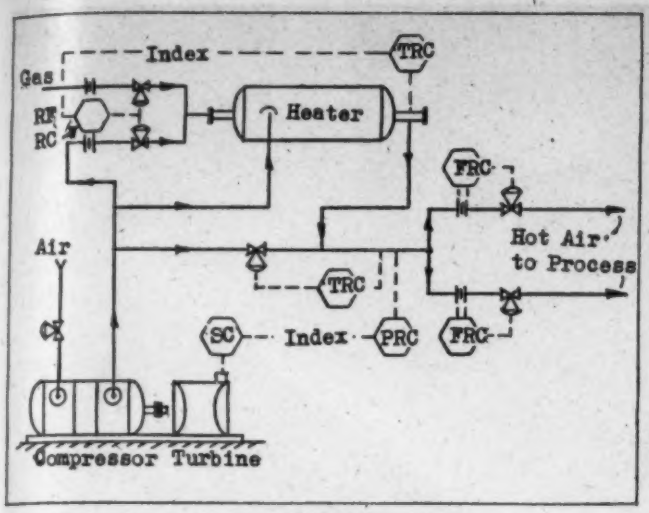

FIGURE 14
Cat cracker hot air system.

operate at low capacity for a protracted period, means may be provided for shutting off one or more of the turbine steam nozzles. On small installations, and if the process controls affected by the driven machine are not complicated, it is possible to use a self operated speed or pressure controller to control the speed of the turbine.

However, on large installations or those in which other process controls are affected by instability of the turbine control, it is necessary to provide precise speed regulation, and to provide the adjustments in the speed controller which will give the required stability. This is particularly true of controllers on turbines which drive centrifugal compressors as these machines have a limited operating range. Should a centrifugal compressor be reduced in capacity to the pumping point, it will drive the turbine and cause it to overspeed. The overspeed trip will then shut down the unit.

Figure 14 shows a turbine driven centrifugal compressor used in connection with the hot air system for fluid bed catalytic cracking plant. The interdependence of the pressure, temperature, flow, and speed control is obvious. On many installations it has been necessary to go to manual operation on one or more of the controllers due to instability of the system. The necessity of proper selection and adjustment of the speed controller of the steam turbine should be apparent. The entire system can be made stable if each unit is adjusted so that it is stable throughout its operating range, and, of course, dead bands or hysteresis must be reduced to a very low value. In addition a suppressed range speed recorder should be provided to assist in adjusting and operating the plant. This control problem is even further aggravated if two turbo-blowers in parallel are used, as small differences in speed of the blowers may lead to one of them operating at an unstable capacity.

Types of speed controllers and their application to process design have been discussed in this paper. Some of the difficulties encountered in the application of speed controllers have been given in detail in order to emphasize that there is much that can be done to improve this phase of instrumentation. If the speed controller manufacturers, the engine manufacturers, and the operating companies are given the opportunity of considering the control problem in its entirety, there is much to be gained in getting the precision in controls which modern processes require.

The speed controller manufacturers could be of great assistance by furnishing data and calibrations for the adjustments which are built into the controller. The adjustments could also be brought out in the open rather than being hidden behind a plug or placing them in a position where it is virtually impossible to reach them while the machine is in operation. They would make certain that the precision built into the controls for a single speed setting is extended so that good precision is maintained for variable speed operation.

The engine manufacturer could be of assistance by providing reaction curves for his machines. This could be accomplished by providing a speed recorder during test runs and obtaining the reaction curves for different loads.

The operating companies could obtain data on installations which are unstable, and the use of a suitable speed recorder is recommended. Hysteresis of the control system can be analyzed and corrections made where necessary. These tests should be undertaken by the instrument departments as they have the necessary specialized training and knowledge which is required.

The ASME have undertaken to provide standard terms for industrial instruments and regulators which would be of assistance in providing common terminology so that all parties involved would speak the same language. A comparison of the terminologies used is given in this appendix.

In closing, the authors wish to request their readers' indulgence for presenting such a broad subject in so limited a paper. They do so with the intention that it may serve at least to stimulate the interest of instrument specialists in the field of speed control as applied to process design and that it will encourage further research in this important field.

APPENDIX 1

Some Standard Process Control Terms[1] and Equivalent Speed Controller Terms

ASME Number	Standard Process Control Terms	Terms Used in Process Speed Controllers
101	Automatic Controller	Governor, Speed Controller, Speed Regulator.
103	Relay Operated Controller	Pilot Operated Governor.
104	Desired Value	Desired Engine Speed.
105	Set Point	Speed Lever Setting, Speed Knob Setting
301	Process	Process
302	Self Regulation	Flywheel Action, Engine Inertia.
303	Controlled Variable	Speed.
304	Controlled Medium	Engine, Turbine, Pump.
305	Manipulated Variable	Rate of Flow of Fuel or Steam.
306	Control Agent	Engine fuel—gas, steam, air.
401	Error	Error
402	Deviation	Regulation.
403	Offset	Droop, Load Error, Regulation.
404	Corrective Action	Response Characteristic.
405	Cycling	Hunting, Oscillating, Instability, Swinging.
501c	Proportional Position Action	Compensation, First Compensation, Relay Action.
502a	Floating Action	Droop Corrector, Compensation, Second Compensation, Dashpot Compensation, Needle Valve Adjustment, Timing Valve Adjustment.
502aa	Single Speed Floating Action	Droop Correction, Compensation, Second Compensation, Dashpot Compensation Needle Valve Adjustment, Timing Valve Adjustment.
502ac	Proportional Speed Floating Action	Droop Correction, Compensation, Second Compensation, Dashpot Compensation, Needle Valve Adjustment, Timing Valve Adjustment.
503a	Rate Action	Accelleration Responsive Governor.
504	Proportional Plus Floating Action	Adjustable Compensation.
601	Neutral Zone	Dead Band.
701a	Primary Element	Speed Sensing Device.
702a	Power Element	Power Piston.
702b	Final Control Element	Throttle Arm, Throttle Valve.
702c	Self-operated Controlling Means	Direct Acting Governor.
702d	Relay-operated Controlling Means	Hydraulic Relay Governor.

[1] As recommended by the Terminology Committee of Industrial Instruments and Regulators Division, ASME.

REVERE detects *VIBRATION* at a distance

DO you know that vibration can be present in the tubes of a condenser, though not perceptible in the shell? Putting the palm of your hand on a condenser is not a good test for destructive vibration. The best test is one carried out in the Revere Research Laboratory in Rome, N. Y., which makes a microscopic examination of the metal as a part of its work in determining causes of tube failure. If vibration contributed to short life, this examination will show it. Vibration accelerates corrosion in several ways. The alternating stresses in time produce cracks across the grain of the metal, weakening it and giving corrosive fluids more points to attack. Vibration also breaks or disrupts or disturbs the thin film on the surface of the metal that protects it and helps reduce the rate of corrosive attack. Of course vibration is but one of a number of factors influencing the service life of condenser tubes, and so when tube life is questioned we always suggest that samples from failed tubes be sent to us. We may be able to help you, as we have others, with suggestions that should materially extend the period between re-tubings.

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REFINER AUTHORS . . . . . and OTHER PERSONALITIES

Texas-Educated Pair Write Article

THE two refinery men who collaborated on one of the most interesting articles in this month's issue of PETROLEUM REFINER (reference is to "Effects of Solvent Composition and Primary Solvent Dilution on Dewaxing Filter Rates and Wax Oil Contents" by E. J. Reeves and I. E. Pattillo, of the technical department, Refining Division, Magnolia Refining Company, Beaumont, Texas, which starts on page 80) both have obtained their education and technical experience in Texas and have chosen—or fate has decreed—that they continue their residence there as they follow their professional lines.

Both are firmly Magnolia men—Pattillo has been with the company continuously since 1928, with some little additional time there starting in 1925, and Reeves was employed in the company's laboratory before taking time out to go away to school.

Processes and operating techniques have been subject to extensive development and alteration during the 20-odd years that Pattillo has been with Magnolia at Beaumont. When he was first engaged there, at experimental work in the wax laboratory, the major process utilized in wax manufacture was the old sweating method. In the years since then, the sweating process has been largely superseded, and the plant has passed through various stages of development including the use of centrifical separation methods, and finally the installation of facilities for solvent dewaxing and deoiling.

Pattillo has been closely associated with this work, and for the past 15 years has handled a variety of problems related to wax manufacture, and dewaxing. During the last two years he has been a member of a technological group as a process engineer in charge of wax refining.

He says that his time away from the plant is divided between the demands of a daughter six-months old, and a long established knowledge of the best places in the area for hunting and fishing. The story is that any time the weather permits, Pattillo will be found on the bank of whichever stream is expected to provide worthwhile results.

I. E. PATTILLO

E. J. REEVES

Reeves, as mentioned above, had worked for Magnolia before entering Rice Institute, Houston, where he received his degree in chemical engineering in 1943. Upon graduation, he rejoined the company, this time as a process engineer, and he is now supervisor process engineer, with duties that cover work with solvent dewaxing, wax manufacture, lubricating oil decolorization, and related problems. His work in the plant has included a variety of experience with waxes and lubricants, and a term with catalytic cracking. This last assignment must have been quite a workout for a lube expert although Reeves admits to no especial difficulties.

He is an active member of the American Chemical Society and its Petroleum Division and at present serves as articles editor for *The Condenser,* monthly publication of the local ACS section, and is a member of the section's publicity committee.

Reeves, not to be outdone by his friend Pattillo, also is the proud father of a daughter now three months old. Some more of the "spare time" goes into work for the chemical abstracts division of the ACS, and it finally becomes difficult to understand just where time is found for the considerable volume of technical writing which he has turned out in recent years. Included in these writings were "Optimum Dilution in Viscous Liquid Filtration" which was published in *Industrial and Engineering Chemistry,* Rotation Speed in Continuous Filter Operation" published in PETROLEUM REFINER, and "Optimum Temperature Gradient in Selective Solvent Extraction" presented before a regional ACS meet.

Busy Since 1929 With Instruments

A VETERAN in instrumentation is the author of "Control of Narrow Boiling Range Fractionating Columns" which is presented on pages 116 and 117. He is G. G. Gallagher of Universal Oil Products Company, Chicago, whose work has taken him into scores of refineries, many of them in foreign lands.

Gallagher's experience with instruments for control of refining operations dates from 1929 when he was with Cities Service Oil Company. In that year he was assigned to installation of instruments and control equipment in the Cities Service refinery, at that time under construction in East Chicago. When that job was done, Gallagher transferred to the operating department in charge of instrument maintenance.

Joining Universal in 1937, as field instrument engineer, he has worked on control problems in some 70 refineries in the United States, Canada, Mexico and Trinidad, B.W.I. Just after Pearl Harbor, Gallagher was called into Universal's Chicago office to head up the instrument department.

Gallagher's hobbies are taking and exhibiting home movies, and sailing. So he's fixed whether the weather man comes up with sunshine or rain, fair days or storm.

G. G. GALLAGHER

J. C. HUTCHESON

J. S. CONNORS

Both Experts—

Process Water Treatment Their Topic

IN THE notes on his personal history, we find that James S. Connors, Phillips Petroleum Company, Bartlesville, Okla., who presented the prepared discussion on the paper by J. C. Hutcheson, "Gasoline Plant Process Water Treatment," was born in Denver, Colorado, April 6, 1909.

After attending public school in Denver, Connors enrolled in the University of Colorado at Boulder, and was graduated in 1931 with a B. A. degree in geology—a rockhound! Further study of the notes, however, indicates that this handicap did not prove detrimental to his welfare. Immediately after school he went to work for Phoenix Utility Company as an inspector of pipe line construction in Butte, Mont. Then in September, 1933, he joined Cities Service Oil Company as analytical chemist at the Ponca City refinery and during off hours studied additional chemistry at the Northern Oklahoma Junior College at Tonkawa. Being something of a determined young man, he also attended night classes in various phases of petroleum and chemical engineering sponsored by the company's engineering group and the state of Oklahoma. While with Cities Service he specialized in treating and corrosion problems.

In February, 1942, he joined Phillips as a chemical engineer in the process design and development section of the natural gasoline department, and in the last five years has designed and supervised the design and operation of several gas treating and gas dehydration plants, gasoline treating units, and boiler and plant water treating systems. Presently, he is supervising the design and development of all treating equipment and its operation.

He is an active member of the American Chemical Society. Outside of process work, his chief interests are golfing and hunting.

J. C. HUTCHESON, author of the paper "Gasoline Plant Process Water Treatment," beginning on page 110 of this issue is a native Missourian, who gives his birthplace as Rothville. We believe that he became of age in that locality and attended the University of Missouri as a special student. According to rumor he boarded the water wagon almost immediately after school. Hutcheson is widely known as an authority in the field of water treating and equipment.

After spending some 12 years as sales and service engineer for McFarland Engineering Company and Graver Tank and Manufacturing Company, specializing in water treating equipment, he joined Shell Oil Company, Inc., as water treating engineer (1936). Presently, Hutcheson is salt water disposal engineer for the Kansas division of Shell and makes his headquarters at Great Bend.

He is very proud of a daughter who is attending Oklahoma A. & M. College at Stillwater. Hutcheson may be found, or not found, roaming over several states indulging in his hobbies of hunting and fishing anytime he can find time from his duties. Since fishing requires some treatment of water, it is generally conceded that Hutcheson has an inside track on the I. Walton sport.

Republic Engineer Tells of Safety Plan

HOLLAND Howell, chief engineer, Republic Oil Refining Company, Texas City, is author of "Management and Employes See Safety Program Pay Off," the article beginning on page 75 of this issue. A friendly, quiet-spoken, hard-working engineer, Howell has packed the article with information that describes Republic's safety program and tells how it is paying off in reducing human suffering and providing a higher plant operating efficiency. Many other plants throughout the industry would do well to initiate a similar program.

Howell's parents were just about as far out West as they could get without leaving Texas and the Rio Grande River, when he was born in El Paso. But prep school found him at Chamberlain-Hunt Military Academy in the deep South at Port Gibson, Miss. Then, as usual with most Texas men, he came back to the Lone Star State and completed his schooling at the University of Texas.

The next six years, Howell divided evenly between the State Highway Department and the United States Engineers. After two years with The M. W. Kellogg Company, he joined Republic, and has been with that company for the past four years. His interest in safety work, he reports, started during his employment with the U. S. Engineers.

Too late for inclusion in the article, came data from the last meeting of Republic's supervisor's safety council meeting, when 105 suggestions had been received by the hazard suggestion committee. Fifty-nine were processed and the necessary work done to eliminate the hazards; five were ruled non-hazardous; two are waiting on material, and 38 are in the process of being eliminated. Definitely fast action, in our opinion.

Some encouraging figures representing losses in dollars and cents against premiums paid for Workmens' Compensation Insurance were given.

The lost-time accident ratio in excess of premiums paid in 1946 was 100.22 percent; in 1947 it was 56.61 percent, and to date in 1948 is 3.25 percent.

Thus the program which Howell outlines continues to show progress.

HOLLAND HOWELL
(In Safety Committee Role)

Refinery and Other Plant Construction

FURTHER revisions are contained in this month's "box score" detailing refinery and other plant construction projects. The "box score" first appeared in the September issue of PETROLEUM REFINER and since that time has become very popular. A number of suggestions have been received and these, together with other data sent in by readers, give promise toward making the compilation more and more complete as the industry becomes advised as to its purpose and intent.

Companies whose projects are not listed are urged to: 1) send in data on units not listed; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such helpful cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST COAST									
Aetna Oil Co.....	Louisville, Ky.	Gasoline Recovery Unit	800 mcf	$75,000	Under Constr.	.....	.....	Aetna	Aetna
Atlantic Ref. Co....	Philadelphia, Pa.	Propane, lubes Wax Plant	3,800 bbls.	.....	Under Constr.	Early '48	JUIK, Texaco	Badger, Atlantic Kellogg & Lummus	Badger, Lummus Kellogg Atlantic, Lauter Constr.
Gulf Oil Corp.....	Philadelphia, Pa.	Naptha, Polyform	16,000 bbls. (circ.)	.....	Under Constr.	.....	Gulf-Phillips	Lummus	Lummus
Sinclair Refg. Co....	Marcus Hook, Pa.	CatCracker, Poly Plt, Vac. Still	49,000 bbls.	.....	Under Constr.	Early '48	.....	.....	Braun
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Lube Plant	.....	Part of $45 million	Under Constr.	Jan. 1, 1949	Texaco	Badger	Badger
Standard Oil Co. (New Jersey)	Linden, New Jersey	Vac. Cat Cracking, pipe still coker	90,000 bbls.	.....	Contract let	1st Qtr. 1949	.....	S.I.D. & Braun	Braun
Sun Oil Co.....	Marcus Hook, Pa.	Lube, Wax, Anti-Pollution Project	.....	.....	.....	.....	.....	.....	.....
The Texas Co.....	Eagle Pt., New Jersey	Vac. still, Cat Cracking	40,000 bbls.	.....	Contract let	Late '49	.....	Kellogg, Texaco Co.	Kellogg, Foster-Wheeler
MID-CONTINENT									
Bareco Oil Co.....	Wichita, Kans...	Cat. desul. Reforming	7,500 bbls.	$500,000	Under Constr.	Early '48	Phillips	Koch Eng. Co...	Koch Eng.
Berry Asphalt Co...	Waterloo, Ark.	Lub Unit, Expand Asphalt facilities	1,200 bbls.	.....	.....	Mid '48	.....	.....	.....
Berry Asphalt Co..	Stephens, Ark.	Expand Asphalt Facilities	2,000 bbls.	.....	.....	Mid '48	.....	.....	.....
Champlin Refining Co.	Enid, Okla.	Phenol Lubricating Oil Extraction	700 bbls.	$300,000	Testing	.....	Kellogg	Koch	Champlin
*Cities Service Oil Co.	Chicago	Compounding & Grease Plant	44,000 gals. lub, 15,000 lbs. Grse	$2.5 million	Projected	Mid '49	.....	.....	.....
Cities Service Oil Co. (Delaware)	E. Chicago, Ill	Modernize plant	.....	$18 million	Under Constr.	Late '48	Kellogg	Kellogg	Kellogg
Cities Service Oil Co. (Delaware)	E. Chicago, Ill	Laboratory	.....	$300,000	Under Constr.	Spring '48	.....	Cities Service	Sumner-Sollitt
Consumer Co-operative Association	Coffeyville, Kansas	MEK Dewaxing	2500 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
Fen Tex. Ref. Co.[3]	Wynnewood, Okla.	Asphalt Plant	.....	.....	.....	.....	.....	.....	.....
Gulf Ref. Co.....	Toledo, Ohio	Crude Unit	.....	.....	Under Constr.	Oct. '48	.....	Badger	Badger
Otha A. Grimes....	Holdenville, Okla.	Gasoline Plant	400,000 mcf	.....	.....	.....	.....	.....	.....
Hagy, Harrington & Marsh	Hooker, Okla.	Gasoline and LPG Recovery	100,000 mcf	$2 million	Under Constr.	July 1, '48	.....	Pritchard	Pritchard
Hiwan Oil Co.....	Arkansas	Gasoline Plant	.....	.....	.....	.....	.....	Petro. Eng.	Petro. Eng.
Kanotex Refg. Co..	Arkansas City, Kans.	Cat Cracking	4,200 bbls.	$500,000	Contract let	Early '48	Phillips	Koch Eng.	Koch Eng.
Mid-Continent Pet. Co.	Tulsa, Okla..	Vac still, Cat Cracking	45,000 bbls.	$8.5 million	Contract let	June, '48	Kellogg	Kellogg	Kellogg
National Co-Op. Ref. Assn.	McPherson, Kansas	Cat Desul and Ref. Unit	5,000 bbls.	$400,000	Under Constr.	.....	Phillips	Koch Eng.	Koch Eng.
Ohio Oil Co.....	Robinson, Ill....	Vac Unit, Cat Cracking	27,500 bbls.	$15 million	Under Constr.	Late '48	U.O.P.	McKee	McKee, Pritchard
Old Dutch Ref. Co..	Muskegon, Mich.	LPG Recovery	3,400 gallons	$45,000	.....	.....	U.O.P.	Old Dutch	Old Dutch
Petco Corporation..	Blue Island, Ill.	Skim. & Crkg.	10,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
*Phillips Pet. Co...	Kansas City, Kansas	Cat Cracking, Poly and Vacuum Units	.....	.....	Contracted	.....	.....	Braun	Braun
*Rock Island Refg. Co.	Rock Island, Ind.	Fluid Cat Crk.	10,000 bbls.	.....	.....	Early '49	.....	.....	.....
*Root Pet. Co.....	El Dorado, Ark.	Revision of Cat. Cracker	7,000 bbls.	$125,000	Under Constr.	May, 1948	.....	U.O.P.	None
Sinclair Refg. Co....	East Chicago, Ill.	Crude Cat. Cracker, Poly Plant & Lube Treating	55,000 bbls.	.....	Under Constr.	Early '48	.....	Lummus	Braun, Lummus
*Skelly Oil Co.....	Stephens Co., Okla.	Gasoline plant	.....	.....	.....	.....	.....	.....	Born
Socony-Vacuum Oil Co., Inc.	E. St. Louis, Ill.	Thermal Cracker & distillation	.....	Part of $45 million	Contract let	Jan. 1, 1949	.....	Bechtel Corp.	Bechtel Corp.
Socony-Vacuum Oil Co., Inc.	Augusta, Kans.	Cat Cracking	10,000 bbls.	Part of $45 million	Projected	.....	.....	.....	.....
Stanolind O & G Co.	Hugoton Field, Kansas	Gasoline Plant	150,000 mcf	.....	Approved	.....	.....	J & L Constr.	J & L Constr.
Stanolind O & G Co.	Hugoton Field, Kansas	Gas syn. Plant	100,000 mcf	.....	Announced	.....	.....	Hydro Res.	Kellogg, Foster-Wheeler, Stone & Webster
Stanolind O & G Co.	Hugoton Field, Kansas	Chemical Plant	130,000 lbs./yr.	.....	Announced	.....	.....	Badger	Badger
Stanolind Oil & Gas Co.	Ulysses, Kan.	Gasoline Plant	100,000 mcf.	.....	Projected	.....	.....	.....	.....
Standard Oil Co. (Indiana)	Sugar Creek, Missouri	Cat Cracking	25,000 bbls.	.....	.....	Early '48	.....	.....	Kellogg
Standard Oil Co. (Indiana)	Whiting, Indiana	Cat Cracking	25,000 bbls.	.....	.....	Early '48	.....	Lummus S.O.D. & Braun	Kellogg, Lummus Braun.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard Oil Co. (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$10 million	Contract let	Late '49	U.O.P.	McKee	McKee
Sun Oil Co.	Toledo, Ohio	Anti-Pollution Project	.....	.....	.....	.....	.....	.....	.....
Sunray Oil Co.	Duncan, Okla.	Crude Plant	20,000 bbls.	.....	Under Constr.	.....	.....	U.O.P.	.....
The Texas Co.	Lawrenceville, Illinois	Crude and Cat Cracking	20,000 bbls.	.....	Announced	1950	.....	Foster Wheeler	Kellogg, Foster-Wheeler
The Texas Co.	W. Tulsa, Okla.	Crude and Cat Cracking	30,000 bbls.	.....	Contract let	1949	.....	Texas Co., Kellogg, Foster-Wheeler	Kellogg, Foster-Wheeler
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	1,500 bbls.	.....	Projected	Jan. 1, 1949	.....	Hudson	Hudson
Warren Pet. Corp.	Maysville, Okla.	Gasoline Plant	8,000 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Illinois	Cat Cracking, gasoil. Cracking	8,500 bbls.	$1 million	Under Constr.	Late '48	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
American Republics Corp.	Silsbee, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	Gasoline Plant Constr. Co.
Atlantic Refg. Co.	Dallas, Texas	Geop. Lab. Bldg.	.....	.....	Under Constr.	'48	.....	Atlantic	Wohlfeld
Barnsdall Oil Co.	Benton, La.	Gasoline Plant	.....	.....	Under Constr.	.....	.....	.....	Lummus
Calumet Refg. Co.	Princeton, La.	Modernization of Lube Plant	700 bbls.	.....	Under Constr.	Early '49	.....	.....	.....
Carthage Corp.	Carthage, Field	Gasoline Plant	100,000 mcf	$3.5 million	Under Constr.	Jan. 1, '49	.....	Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Tex.	Hydrocol	64,000 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc., Texaco	McKee	McKee
Citcon Corp.[1]	L. Charles, La.	Lube Plant	6,000 bbls.	$30 million	Under Constr.	.....	Texaco, Max B. Miller	Max B. Miller Lummus Citcon	Lummus, Max B. Miller
Continental Oil Co.	Sonora, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	Brown & Root
Eastern States Petroleum Corp.	Houston, Tex.	Cat Cracking, Improvement Cat. Poly	7000 bbls. 700 bbls.	$300,000	.....	.....	U.O.P.	U.O.P.	Mason Bros., Westheimer
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$20 million	Announcement	.....	.....	.....	.....
Gray-Wolfe Co.	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	Jan., 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane Co., Tex.	Gasoline Plant	23,000 mcf	.....	.....	.....	.....	.....	.....
Gulf Oil Corp.	Pt. Arthur, Tex.	Crude, Poly-Perco	.....	.....	Under Constr.	Early '48	Gulf-Phillips	Badger, Lummus	Badger, Lummus
Humble O & R Co.	Baytown, Tex.	Lube Plant	.....	$5 million	Under Constr.	Early '48	Texaco	Badger	Badger
Humble O & R Co.	East Texas	Gasoline Plant	.....	$2 million	Under Constr.	.....	.....	Fish Eng. Corp.	.....
Humble O & R Co.	Katy, Texas	Propane, Butane Extraction	19,000 bbls.	$7 million	Contract let	.....	.....	.....	Stearns-Roger
Humble O & R Co.	Refugio, Texas	Gasoline Plant	35,000 mcf	$2.5 million	Under Constr.	1948	.....	.....	Gaso. Plant
*Humble O & R Co.	Baytown, Texas	Lube dewaxing	4,600 bbls.	$5 million	Under Constr.	Feb. '48	Texaco	Badger	Badger
*Humble O & R Co.	Kilgore, Texas	Gasoline Plant	150,000 gallons	$2 million	Under Constr.	.....	.....	Fish	Fish
Jefferson Chem. Co.	Pt. Neches, Tex.	Petro-chem	.....	.....	Under Constr.	1948	.....	Jefferson	Jefferson, Badger Lummus
Magnolia Pet. Co.	Beaumont, Tex.	Lube Plant	.....	.....	Under Constr.	Jan. 1, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline Plant	90,000 mcf	.....	.....	Late '48	.....	Hudson	.....
Magnolia Pet. Co.	Mamou, La.	Gasoline Plant	7,000 mcf	.....	Under Constr.	Late '48	.....	.....	Gaso. Plant
Fred M. Manning, Inc.	Stephens Co., Texas	Pressure Maintenance	20,000 mcf	$500,000	Contract let	Jan. '49	.....	Fish Eng. Corp.	.....
McCarthy Chem. Co.	Winnie, Texas	Petro-chem, Cat Cracking	5,000 bbls.	$3 million	Under Constr.	.....	Phillips	Fish Eng. Corp.	.....
Monsanto Chem. Co.	Texas City, Tex.	Rebuilding Petro-chem	.....	$6 million	Contract let	.....	.....	.....	Bellows Co., Leon Con. Co.
Petco Corporation	Marrero, La.	Skim. & Crkg.	5,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
Petrol Terminals	Texas City, Tex.	Cat Cracker (re-condition)	.....	.....	Under Constr.	.....	.....	.....	Cat. Constr.
*Phillips Pet. Co.	Hansford Co., Texas	Gasoline & LPG Plant	343,000 mcf	.....	Announced	.....	.....	.....	.....
Plomo Co.	Nueces Co., Tex.	Gasoline Plant	.....	.....	Awaiting Appr'l	.....	.....	.....	.....
Pure Oil Co.	Smith's Bluff, Texas	Lube Plant	.....	$9 million	Contract let	.....	Texaco	Lummus	Lummus
Richardson and Base	Keystone Field, Texas	Gasoline Plant	70,000 mcf	.....	Constr. Appr'vd	10-1-48	.....	J & L Constr.	J & L Constr.
Shell Chemical Corp.	Houston, Texas	Glycerine	.....	Part $35 mln.	Under Constr.	Early '48	.....	.....	Braun
Shell Oil Co.	Notrees, Texas	Gasoline Plant	45,000 mcf	$4 million	Under Constr.	March '48	.....	Brown & Root	Brown & Root
Shell Oil Co.	Houston, Texas	Lube Unit	2,800 bbls.	$10 million	Under Constr.	July '48	Texaco	Lummus	Lummus, Kellogg, Fluor
Shell Oil Co.	Denver City, Tex.	Gasoline Plant	24,000 mcf	.....	Under Constr.	1948	.....	.....	Fluor Corp.
Shell Oil Co.	Norco, La.	Thermal Cracking, Asphalt Plt.	12,000 bbls.	.....	.....	April '48	.....	Shell	Shell
*Sid Richardson Carbon Co.	Odessa, Texas	Carbon black Plant	194,500 lbs.	.....	Under Constr.	.....	.....	.....	.....
*Sid Richardson Gasoline Co	Kermit, Texas	Gasoline & LPG Plant	200,000 gallons	.....	.....	.....	.....	.....	.....
Sinclair Refg. Co.	Houston, Texas	Crude Still, Barrel House, Grease Works.	30,000 bbls.	.....	Under Constr.	.....	.....	.....	Fluor
*Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	Under Constr.	August, '48	.....	Process Eng.	Process Eng.
Stanolind O & G Co.	Slaughter, Texas	Gasoline Plant	90,000 mcf	.....	Approved	.....	.....	Braun	Braun
Stanolind O & G Co.	Hockley County, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	.....
Stanolind O & G Co.	Brownsville, Tex.	Chemical Plant	130,000 lbs./yr.	.....	Announced	.....	.....	Badger	Badger
Stanolind O & G Co.	Pettus, Texas	Cycling Plant	159,000 mcf	.....	Projected	1949	.....	J & L Constr.	J & L Constr.
Standard Oil Co. (New Jersey)	Baton Rouge, Louisiana	Lub. Vac. still, Crude, Dewax, poly	111,500 bbls.	.....	Under Constr.	Early '48	Texaco	Badger, S.O.D., Braun, McKee, Kellogg	Badger, Kellogg, McKee, Braun
Sun Oil Co.	Richland Parish, Louisiana	Gasoline Plant	70,000 gal.	.....	Under Constr.	.....	.....	.....	Pet. Eng., Inc.
Talco Asphalt & Refining Division American Liberty Oil Co.	Mt. Pleasant, Texas	Poly L.P.G. Plant	26,800 mcf	$225,000	Under Constr.	April 15, '48	U.O.P.	Talco	Talco
The Texas Co.	Port Arthur, Texas	Lube addition	2,000 bbls.	.....	Under Constr.	Late '48	.....	Texas Co., Foster Wheeler	Foster-Wheeler
*The Texas Co.	Lafitte, La.	Expand Gaso-Plant	6,500 mcf	.....	.....	.....	.....	Hudson	Hudson
Warren Pet. Corp.	Breckenridge, Texas	L.P.G. Extraction	1,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Warren
Warren Pet. Corp.	Holliday, Tex.	Expansion & Propane prod.	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Warren
Winnsboro Refg. Co.	Winnsboro, Tex.	Crude Plant	3,000 bbls.	$175,000	Under Constr.	Jan. 1, '48	.....	.....	Mid-Continent
Witco Hydrocarbon Corp.	Big Lake, Texas	Gasoline Plant	2,500 bbls.	$2.6 million	Under Constr.	July '48	.....	Witco	Fish
Witco Hydrocarbon Corp.	Witco, Texas	Carbon Black	.....	Part of $3.5 million	Contracted	.....	.....	Fish	Fish & Witco

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ROCKY MOUNTAIN									
The California Oil Company	Rangely, Colo.	Gasoline Plant	25,000 gals.	$2 million	Under Constr.	'48	.....	Hudson	Hudson
Carter Oil Co.....	Billings, Mont..	Crude Cat Crk..	30,000 bbls.	$20 million	Under Constr.	3rd Qtr. 1949	.....	U.O.P., S.O.D.	Fluor Corp.
Continental Oil Co.	Billings, Mont.	Cat Cracking	7,500 bbls.	$8.5 million	Contract signed	1949	U.O.P.	U.O.P.	J & L Constr.
Continental Oil Co.	Denver, Colo.	Crude, Cat Crk.	7,500 bbls.	$4 million	Under Constr.	Fall 1948	Houdry Corp. & U.O.P.	Con. Oil Co., Lummus	Lummus
Gulf Oil Corp.....	Eunice, N. M.	Gasoline Plant	.....	.....	.....	.....	.....	Hudson	Hudson
*Skelly Oil Co.....	Lea County, N. M.	Expanding Gasoline plant	.....	.....	.....	.....	.....	.....	J. E. Carlson
Socony-Vacuum Oil Co., Inc.	Casper, Wyo.	Cat Cracking	4,000 bbls.	Part of $45 million	Under Constr.	Jan. 1, 1949	.....	Cat. Constr.	Cat. Constr.
Stanolind O & G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Approved	.....	.....	Stone & Webster	Stone & Webster
Standard Oil Co. (California)	Salt Lake City, Utah	Crude dist. unit	25,000 bbls.	$5 million	Announced	Late '48	.....	.....	Bechtel
Utah Oil Refg. Co..	Salt Lake City, Utah	Expand existing Refinery	25,000 bbls.	$2.5 million	Announced	Late '48	.....	.....	.....
Warren Pet. Corp...	Monument, N.M.	Gasoline Plant Enlargement	2,500 bbls.	.....	Under Constr.	Jan 1, 1949	.....	Warren	Dresser Eng.
WEST COAST									
*General Pet. Corp.	Torrance, Calif.	Vacuum flash tower	32,000 bbls.	$558,000	Contracted	3rd Qtr. '48	.....	Braun	Braun
Shell Chemical Corp.	Shell Pt. Calif.	Syn. Ammonia	.....	.....	.....	Early '48	.....	.....	.....
Standard Oil Co. (California)	Bakersfield, California	Crude dist, Cat Cracking	10,000 bbls.	$7.5 million	Announced	Mid '49	.....	.....	.....
Standard Oil Co. (California)	El Segundo, Cal.	Filling Plant Modernization	.....	$2 million	Under Constr.	Dec. '48	.....	.....	.....
Standard Oil Co. (California)	Richmond, (California)	Grease, Wax Plant, Dock Facilities	82,000 lbs.	$13 million	Under Constr.	Sept. '48	U.O.P.	W. G. Peugh	Barrett & Hilp, Swinerton & Walberg & Ben C. Gerwick Inc., Humiston-Rosendahl Inc.
FOREIGN									
Agwi Pet. Corp.....	Fawley, Eng....	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
British Pet. Chem., Ltd.	Grangemouth, Scotland	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Crude Plant	20,000 bbls.	$18 million	Projected	Early '50	.....	McKee	McKee
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	124,000 bbls.	.....	.....	By 1950	Lummus, Kellogg	Lummus	Badger
Creole Pet. Corp....	Amuay Bay, Venezuela	Cat Cracking	60,000 bbls.	$70 million	Under Constr.	1950	.....	.....	.....
Creole Pet Corp.[2]...	Molata Field, Venezuela	Stabilization and Repressuring Plants	.....	.....	.....	.....	.....	.....	.....
Creole Pet. Corp.[3]..	El Roble Field, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Egyptian Government	Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Imperial Oil, Ltd....	Montreal East, Canada	Cat Cracker, Cat Poly	33,000 bbls.	.....	Under Constr.	Early '48	.....	.....	.....
Imperial Oil, Ltd....	Edmonton, Canada	Thermal Cracking, Crude Dist.	6,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
*Imperial Oil, Ltd..	Leduc field	Gas absorption Plant	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantau, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Mene Grande.....	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Petro Carbon, Ltd.	Partington, Eng.	Cat Cracker, Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd...	Partington, Eng.	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
*Petroleos Mexicanos.....	Cindad Madero	Crude unit	25,000 bbls.	$2 million	Under Constr.	July, 1948	None	Own Staff	Own Staff
Petroleos Mexicanos	Salamanca, Mex.	Crude, gasoil Cracking	30,000 bbls.	$12 million	Contract let	1949	U.O.P.	McKee	McKee
Porto Marghera Rfg.	Venice, Italy	Enlarging	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chemical Corp.	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co (Venezuela)	Cardon, Venezuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
*Shell Oil Co.....	Heysham, Eng.	Remodel & redesign Crude Plant	30,000 bbls.	.....	Under Constr.	March, '48	.....	.....	.....
*Standard Oil Co. of British Columbia, Ltd.....	Vancouver, B.C.	Asphalt Plant	175 tons	$500,000	Under Constr.	April, 1948	.....	.....	.....
Stora Kopparberg..	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
*Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.	.....	.....	.....	.....	Foster-Wheeler	Foster-Wheeler
Yacimientos Petroliferos Fiscales, Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1949	.....	Foster-Wheeler	Foster-Wheeler
*YPF Brasil.....	Santos, Brazil	Complete Refg.	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....

NOTE—Atlantic—The Atlantic Refining Co. Badger—E. B. Badger and Sons. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Clark's—Clark's Construction and Engineering Company. Dresser—Dresser Engineering Corporation. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corporation. Gaso. Plants—Gasoline Construction Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. Hydro Res.—Hydrocarbon Research, Inc. Jefferson—Jefferson Chemical Co. J & L Constr.—Jones & Laughlin Construction Co. Koch Eng—Koch Engineering Co. Kellogg—M. W. Kellogg Co. Leon Constr.—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Company. McKee—Arthur G. McKee Co. Old Dutch—Old Dutch Refining Company. Phillips—Phillips Petroleum Co. Pet. Eng.—Petroleum Engineers, Inc. Pritchard—J. F. Pritchard & Co. Process Eng.—Process Engineers, Inc. Stearns-Roger—Stearns Roger Manufacturing Co. Texaco—Texaco Development Co. Warren—Warren Petroleum Corporation. Westheimer—Westheimer Rigging and Heavy Hauling Company. Wohfeld—Wohfeld Construction Co. [1] Jointly owned by Cities Service Oil Co. and Continental Oil Co. [2] Jointly owned with Pantepec Oil Co. [3] Jointly owned with Pantepec Oil Co. [4] Joint project with Cities Service Oil Co., The Carter Oil Co., Sinclair-Prairie Oil Co., with Warren operating plant. [5] Kerr-McGee Oil Industries, Inc. interest.

* First appearance in tabulation

Synthetic Fuels and Oil Demand—

Refinery Output Must be Upped; Synthetic Needs Outlined

U. S. refineries were operated at maximum rates during 1947, producing record quantities of petroleum products. With increased demand forecast and stocks of refined products uncomfortably small, U. S. refineries again will process record volumes during the current year.

During 1947 a total of 1,849,931,000 barrels of crude oil was run to refining stills, an average of 5,068,000 barrels daily. This represented an increase of 6.9 percent or 328,000 barrels daily over 1946 levels, and was 1,200,000 barrels per day greater than in 1941.

At the end of 1947 the nation's refining capacity had been increased to 5,671,000 barrels per day in contrast with 5,559,000 barrels 12 months previous. And at the end of 1947 there was 93.9 percent of the existing capacity being used in contrast with only 86 percent at the close of 1946. Consequently, the amount of crude oil charged to refining stills in December averaged 5,324,000 barrels per day in contrast with the year's average of 5,069,000 barrels. Nevertheless, not enough petroleum products were being refined, so sharply had consumption increased.

During 1948 some additional refining capacity will become available, but it will not be sufficient to answer all needs.

Chief concern the past year was the problem of manufacturing enough gasoil and distillate fuel oils to satisfy requirements. Production of distillate fuel oils, which include heating oils, necessarily has been increased more rapidly since 1941 than output of other products. By adjusting upward the amount of distillate fuel recovered from crude run to stills, refiners were able to produce 309,927,000 barrels of this product last year. This was equivalent to a daily average yield of 849,000 barrels, an increase of 7.6 percent over the 789,000 barrels produced daily in 1946, and 63.8 percent more than the 518,000 barrels produced daily in 1941.

The record-breaking quantity of distillate fuel oils produced was not sufficient to satisfy demand, and stocks of these products at the close of the year were 9 million barrels less a year previous.

Production of gasoline (including

Crude Runs to Stills at U. S. Refineries and Percent of Refinery Capacity Used, By Districts, December and Years, 1941, 1946, and 1947

Runs from Bureau of Mines, except November and December, 1947, from American Petroleum Institute; Capacities from American Petroleum Institute.
(THOUSANDS OF BARRELS)

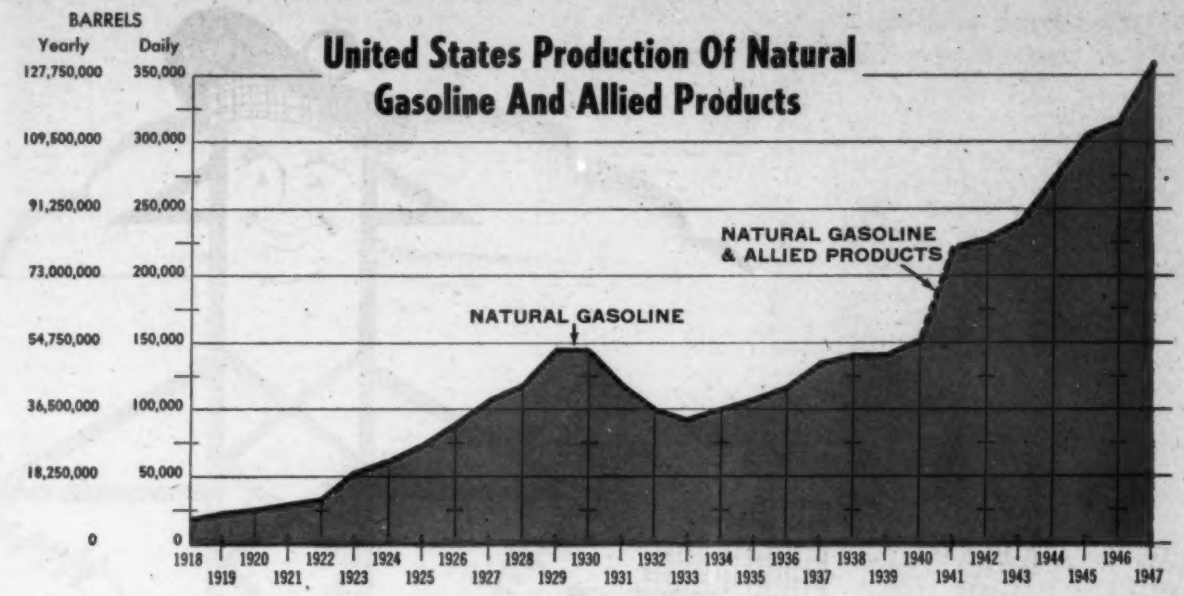
	CRUDE RUN IN DECEMBER							REFINING CAPACITY AND USE IN DECEMBER						CRUDE RUN DURING YEAR						
	Total Amount Run During Month				Daily Average Run During Month			Daily Capacity			Percent Capacity Used			Total Amount Run During Year			Daily Average Run During Year			
Refining District	Dec. 1941	Dec. 1946	Dec. 1947	% Diff. 1946-1947	Dec. 1941	Dec. 1946	Dec. 1947	Dec. 1941	Dec. 1946	Dec. 1947	Dec. 1941	Dec. 1946	Dec. 1947	1941	1946	1947	1941	1946	1947	% Diff. 1946-1947
East Coast	19,750	23,343	25,357	+ 8.6	637	753	818	704	839	819	90.5	89.7	99.9	217,046	276,651	296,379	595	758	812	+ 7.1
Appalachian	4,575	4,960	5,251	+ 5.9	148	160	169	174	205	188	85.1	78.0	89.9	53,499	55,756	60,497	147	153	166	+ 8.5
District No. 1	.....	3,020	3,079	+ 2.0	.....	97	99	.....	143	123	.....	67.8	80.5	.....	35,049	35,980	.....	96	99	+ 3.1
District No. 2	.....	1,940	2,172	+ 12.0	.....	63	70	.....	62	65	.....	101.6	107.7	.....	20,707	24,517	.....	57	67	+ 17.5
Ill., Ind., Ky.	22,078	23,710	26,393	+ 11.3	712	765	851	776	870	949	91.8	87.9	89.7	251,257	279,810	300,507	688	767	823	+ 7.3
Okla., Kans., Mo.	10,711	11,887	13,822	+ 16.2	346	383	446	418	469	454	83.3	81.7	98.2	127,130	138,385	153,741	348	379	421	+ 11.1
Texas Inland	5,761	6,689	7,810	+ 16.8	186	216	252	265	330	290	70.2	65.5	86.9	66,640	78,812	84,470	183	216	231	+ 6.9
Texas Gulf	33,919	36,246	41,524	+ 14.8	1,094	1,169	1,343	1,117	1,227	1,310	97.9	95.4	102.5	363,252	424,619	437,245	995	1,163	1,198	+ 3.0
Louisiana Gulf	4,925	10,648	12,421	+ 16.7	159	344	401	172	321	352	92.4	107.2	113.9	54,300	121,215	139,883	149	332	383	+ 15.4
Ark., and La. Inland	2,613	1,923	2,456	+ 27.1	84	62	79	97	126	113	86.6	49.2	69.9	29,365	21,967	24,705	80	60	68	+ 13.3
Rocky Mountains	2,848	4,307	4,732	+ 12.5	92	136	153	137	178	183	67.2	76.4	83.6	33,570	48,044	52,254	92	131	143	+ 9.2
District No. 3	.....	332	323	— 2.7	.....	11	11	.....	13	13	.....	84.6	84.6	.....	4,034	3,770	.....	11	10	— 9.1
District No. 4	.....	3,875	4,409	+ 13.8	.....	125	142	.....	165	170	.....	75.8	83.5	.....	44,010	48,484	.....	120	133	+ 10.8
California	17,805	24,548	25,171	+ 2.5	574	792	812	787	994	1,013	72.9	79.6	80.2	213,133	284,938	300,250	584	781	823	+ 5.4
Total United States	124,985	148,171	165,037	+ 11.4	4,032	4,780	5,324	4,647	5,559	5,671	86.8	86.0	93.9	1,409,192	1,730,197	1,849,931	3,861	4,740	5,068	+ 6.9

United States Crude Runs to Stills.

(All Figures In Barrels)

YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average
1918	326,025,000	893,200	1926	779,264,000	2,135,000	1934	895,636,000	2,453,800	1942	1,334,103,000	3,655,000
1919	361,520,000	990,500	1927	828,835,000	2,270,800	1935	965,790,000	2,646,000	1943	1,429,738,000	3,917,000
1920	432,915,000	1,185,600	1928	913,295,000	2,495,300	1936	1,068,570,000	2,919,000	1944	1,665,884,000	4,551,000
1921	443,363,000	1,214,700	1929	987,708,000	2,706,100	1937	1,183,440,000	3,242,000	1945	1,719,534,000	4,711,000
1922	500,706,000	1,371,800	1930	927,447,000	2,541,000	1938	1,165,015,000	3,191,800	1946	1,730,197,000	4,740,000
1923	581,238,000	1,592,400	1931	894,608,000	2,451,000	1939	1,237,840,000	3,391,000	1947	1,849,931,000	5,068,000
1924	642,719,000	1,758,800	1932	819,997,000	2,240,400	1940	1,294,283,000	3,536,300			
1925	739,930,000	2,027,200	1933	861,254,000	2,359,000	1941	1,409,192,000	3,860,800			

Source—U. S. Bureau of Mines, except for latest year which has been calculated from Bureau statistics for first 10 months and American Petroleum Institute weekly reports for the last two months.



United States Production Of Natural Gasoline And Allied Products

(All Figures in Barrels)

YEAR	Annual Production	Daily Average	YEAR	Annual Production	Daily Average	YEAR	Annual Production	Daily Average	YEAR	Annual Production	Daily Average
1918.....	6,727,000	18,430	1926.....	32,455,000	88,917	1934.....	36,556,000	100,153	(*) Natural Gasoline and Allied Prod.		
1919.....	8,370,000	22,931	1927.....	39,075,000	107,054	1935.....	39,335,000	107,761	1941.....	80,855,000	221,520
1920.....	9,161,000	25,098	1928.....	43,191,000	118,331	1936.....	42,770,000	117,178	1942.....	83,322,000	228,279
1921.....	10,713,000	29,350	1929.....	53,183,000	145,706	1937.....	49,177,000	134,731	1943.....	87,716,000	240,318
1922.....	12,044,000	32,997	1930.....	52,631,000	144,194	1938.....	51,347,000	140,676	1944.....	100,046,000	273,350
1923.....	19,434,000	53,243	1931.....	43,617,000	119,498	1939.....	51,650,000	141,507	1945.....	112,004,000	306,860
1924.....	22,235,000	60,197	1932.....	36,281,000	99,400	1940.....	55,700,000	152,502	1946.....	115,153,000	315,488
1925.....	26,845,000	73,547	1933.....	33,810,000	92,630				1947.....	131,370,000	359,918

* Bureau began a new series covering 1941 and subsequent year, which includes cycle condensate.

straight run, cracked and natural blended at refineries) during 1947 totaled 814,150,000 barrels, or 2,231,000 barrels daily. At this level it was 8.8 percent more than the 2,050,000 barrels manufactured daily in 1946. This was the highest percent gain for the year of any of the major petroleum products, but still the growth of gasoline production since 1941 has been smaller than any other major petroleum product, having gained but 21.3 percent. This rate of producing gasoline permitted stocks of this product to be maintained during the year.

Natural Gasoline

The upward trend in U. S. production of natural gasoline and allied products was accelerated during 1947. This was the 15th consecutive year in which record quantities of those products were produced, and prospects are that another new peak will be established in 1948.

A total of 131,370,000 barrels of natural gasoline, cycle products and liquefied petroleum gases was produced the past year, an increase of 16,217,000 barrels, or 14 percent, over the 115,153,000 barrels manufactured in 1946. The growth of natural gasoline and allied products has been phenomenal in recent years, having risen nearly one-third since 1944.

Output in 1947 was equivalent to an average of 360,000 barrels daily, up 44,500 barrels from the 135,500 barrels of the preceding year. This was, by a substantial margin, the sharpest annual gain ever recorded

At the end of the year production of natural gasoline and allied products already had increased to 375,000 barrels daily. With some additional plants due to be placed in operation during the year, it is indicated that output in 1948 can be expected to average about 385,000 barrels daily to reach an annual total of approximately 140 million barrels for the year.

The Need for Synthetic Fuels

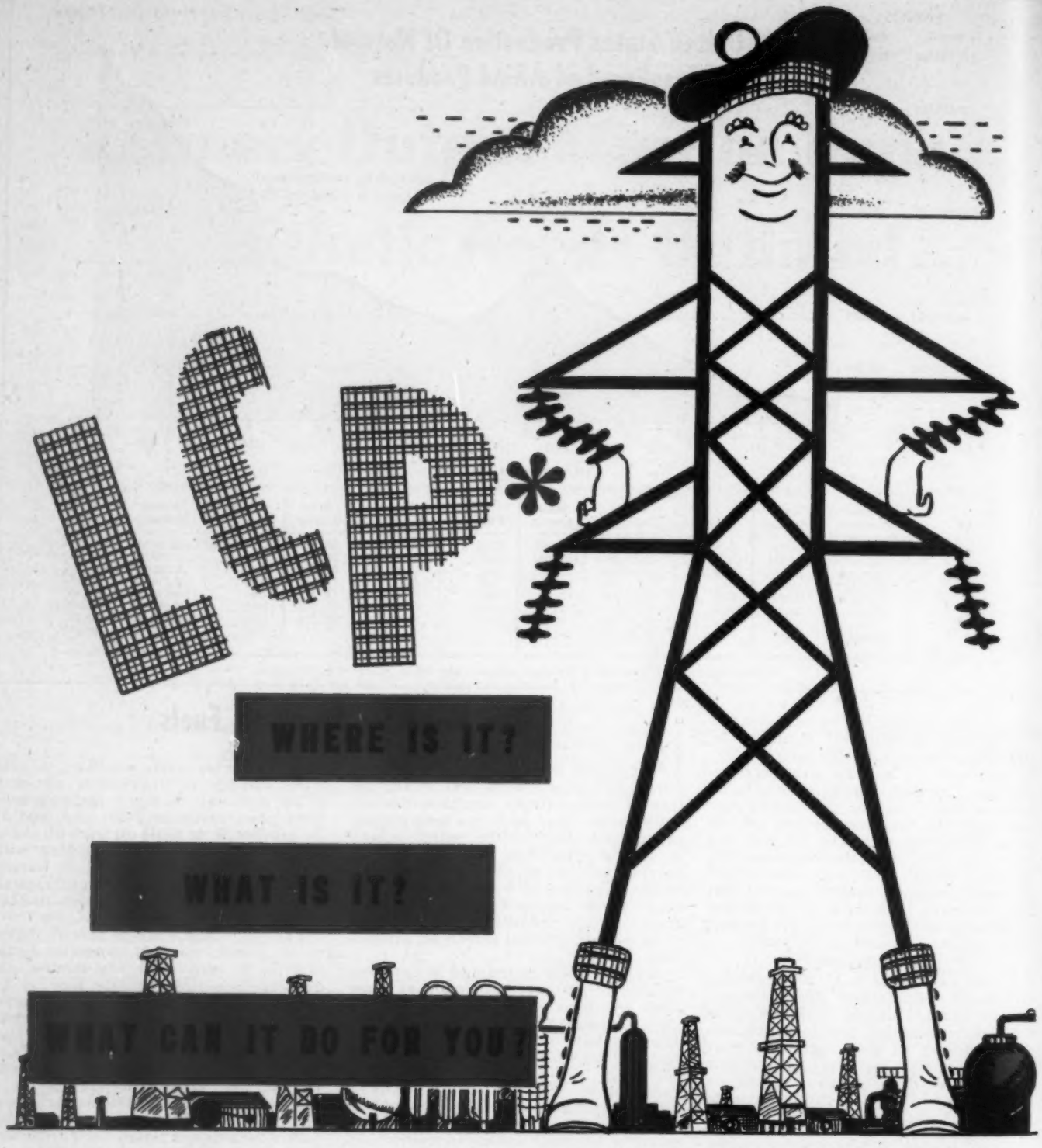
BECAUSE of shortages of petroleum during and after World War II and the fear of serious future shortage, interest in synthetic liquid fuels has been greatly encouraged. Just as the nation solved its almost disastrous wartime loss of natural rubber supply by developing synthetic rubber, so it now considers the need for setting up facilities for large-scale synthetic production of liquid fuels to supplement natural petroleum production.

A bill has been introduced in Congress seeking to assure construction of three large synthetic plants underwritten by the government. The Secretary of the Interior, with support from the Secretary of Defense, has recommended that the U. S. start at once on a $9 billion program of construction of synthetic liquid fuel plants. The plants would be built within five to ten years, with government financial aid if necessary, and would provide a synthetic liquid fuels industry capable of producing 2 million barrels of products per day. The bill for immediately starting three plants would be the first step in the program recommended by Secretary of Interior Julius A. Krug, with approval of Defense Secretary James V. Forrestal.

The bill H.R. 5475, introduced in the House by Chairman Wolverton, Republican, New Jersey, of the Interstate and Foreign Commerce Committee, would authorize construction of three basic commercial-scale, 10,000 barrels per day synthetic liquid fuel plants for a total maximum cost of $400 million. Under provisions of the bills these plants would be of three different types and would each have a capacity of not less than 10,000 barrels per day of liquid fuels. The three plants would be of these types: 1) for hydrogenation of coal, 2) for synthesis of liquid hydrocarbons from gases produced from coal, and 3) for production of shale oil from oil shale. The plants would be constructed with the technical advice of the U. S. Bureau of Mines, which is carrying on research in synthetic liquid fuels under another law that is to be extended.

The bill would leave to private industry a fourth class of synthetic liquid fuel plant: converting dry natural gas into gasoline and distillate fuel oil by the Fischer-Tropsch process. There is already a start on commercial development of this kind of production. Two such plants, one at Brownsville, Texas, and the other in the Hugoton area, Kansas, are under construction, at a cost exceeding $15 million each, and each of them will produce about 7500 barrels per day of liquid fuels from dry natural gas. These plants promise to be commercially competitive with refineries making similar products from crude petroleum, and it has been estimated that production of this kind will climb to at least 200,000 barrels daily by 1956. (See page 156.) Natural gas reserves, though large, are small in comparison with coal reserves and do not warrant too large a gas-to-gasoline synthetic industry, especially in view of the desirability of natural gas as a fuel in its natural state.

Coal reserves are very large so the current clamor for synthetic developments lays principal emphasis on utilization of coal for making liquid fuels. Of the three proposed plants, two would make use of coal, one by hydrogenation and the other by changing coal into gaseous then liquid form. The third type



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plant would seek to develop more satisfactory extraction of oil from oil shale, present methods being non-competitive with crude oil refining.

Under the Wolverton bill, the Reconstruction Finance Corporation would be authorized to extend funds to private interests for building the plants and if plants were not so built, RFC would have to build them, then lease them to private interests for operation.

Wolverton said hearings of his committee convinced him that military and economic security required prompt steps toward a synthetic liquid fuel industry, so handled as not to replace domestic crude production or imports of foreign oils, and with due regard to the need of using steel moderately.

Situation as to Steel

While the Krug recommendation contemplates use of 16 million tons of steel and a total cost of $9 billion to develop 2 million barrels per day of synthetic capacity, Wolverton said:

"To suggest to Congress at this time to approve such expenditures would be pure foolishness and would merely serve to deteriorate, so far as the next three to five years are concerned, our petroleum situation, since it would consume the steel which is so urgently needed at home and abroad to supply us with domestic and imported crude. On the other hand, it is wisdom to set aside a small portion of the steel which generally will be available during the next three years, to construct the three basic plants which will advance immeasurably our ability to increase domestic production of liquid fuels should the need therefor increase."

The Krug recommendations were embodied in an annual report to Congress on progress of the government synthetic liquid fuels research, and they made these assumptions: 1) that the need for a synthetic liquid fuel industry is clear and urgent, from a national defense standpoint; and 2) that such an industry will not be initially competitive with the crude oil industry and therefore requires government assistance.

Krug said that establishment of a synthetic liquid fuels industry is "far too large an operation and requires too much time to be undertaken under wartime emergency conditions." He said that a synthetic fuels program would be 10 times greater than the wartime synthetic rubber program.

Secretary Krug cited skyrocketing demand for petroleum products and the uncertainty that domestic supplies would overtake that demand in the future and urged immediate action by Congress to extend the synthetic liquid fuels research program from June 30, 1949, until June 30, 1951, and to appropriate another $30 million for the project. Both House and Senate have passed this bill but a minor difference in House and Senate versions has to be compromised. Krug stated that all research laboratories and the oil shale demonstration plant contemplated under the existing legislation are now in full operation and that a coal hydrogenation demonstration plant, to be located at Louisiana, Mo., will be in service by next summer.

Oil Shale Plant

Krug's report stated that at Rifle, Colo., a demonstration plant produced its first crude shale oil last May. Since then, production has been at the rate of about 50 barrels daily, and now three additional types of retorting units are being built. The present estimated cost of producing crude shale oil on a large scale is roughly $2 to $2.50 per barrel, according to the report. "This oil would not compare favorably in quality with oil produced from natural petroleum now selling at those prices but if the recent trend toward price increases continues, it will be easily competitive."

By relatively simple refining, crude shale oil yields No. 5 or No. 6 residual fuel oil suitable for use in ships or utility plants. But further improvements in refining will be necessary to produce distillate fuel oil, diesel fuel, and gasoline on a commercial basis. In order to speed up studies of the government on refining methods, it will undertake a cooperative program with a number of oil companies.

The demonstration plant at Louisiana, Mo., for converting coal into oil will be completed this year. It will produce about 200 barrels per day of gasoline by the hydrogenation process. Under present conditions it is estimated that high grade motor gasoline or aviation gas can be produced through this process for about 14 cents per gallon, about 5 to 7 cents more per gallon than the current cost of gasoline from petroleum. In this estimate no credit is given for by-products which may reduce the cost in some plants by 3 to 5 cents per gallon. The estimate does include allowance for plant amortization and production costs.

Krug's recommendations were challenged by Bruce K. Brown, chairman of the military petroleum advisory committee and vice president of Standard Oil Company (Indiana). He declared that first preference must be given to producing liquid fuels from crude petroleum because such production is so much less costly in steel and manpower than production by any other method.

Even the starting of a few large synthetic plants at this time, he said, "would, because of their enormous requirements for steel, cut down the immediate availability of oil by depriving the industry of steel it needs this year and next year."

Brown took the view that if crude oil becomes seriously scarce, all the really needed liquid fuels can and will be synthesized by private industry from natural gas and coal. In this connection, he contended that synthetic liquid fuels are and will remain practical only in such forms as aviation gasoline, motor fuel, or diesel oil, where coal or other substitutes cannot be used. The synthetic fuels are too costly and wasteful of the original heat value of natural gas and coal to be made for use in furnaces and under boilers, he asserted. "It would be folly," he declared, "to sponsor a national program to subsidize the production of liquid fuel to burn under boilers." The country "cannot afford to build plants to make fuels to heat houses," because "we're just not that rich."

To produce 2 million barrels per day of synthetics from coal, said Brown, would require 468 million tons of coal per year or more than two-thirds as much as was ever produced in a single year. To synthesize only about 500,000 barrels per day of liquid fuel, he said, all of the available natural gas produced in the U. S. in 1946—4.83 trillion cubic feet—would have been required, with nothing left for electric power from gas, for industrial use, or for heating factories, commercial places, and homes.

Brown did not challenge the practicability of synthetic liquid fuels "to power the really efficient mechanisms where they are needed and for which there is no substitute."

"Stick to South America"

Asked what Congress could do to assure adequate supply of oil for an emergency, Brown said one of the most important things should be to establish and maintain the best possible relationships with South America as the "safest source" of oil outside the U. S. He also recommended that the oil industry get more steel to develop domestic reserves and that everything possible be done to facilitate development of tidelands oil. In the latter connection, he urged that the federal government turn title over to the states because administration of the lands by a federal agency would obstruct development.

Ohio Standard Sets New Refining Record in 1947

The Standard Oil Company (Ohio) during 1947 processed 1438 million gallons of crude oil at its refineries, a new record that tops the highest previous year by 11.5 percent.

Highest previous year for the Sohio refineries was 1946, when 1281 million gallons of crude oil were processed.

The 1947 record-breaking total is 24 percent above 1944, highest wartime year; and 88 percent above 1939, the so-called "normal" year.

Trends of Operations and Changes in Stocks

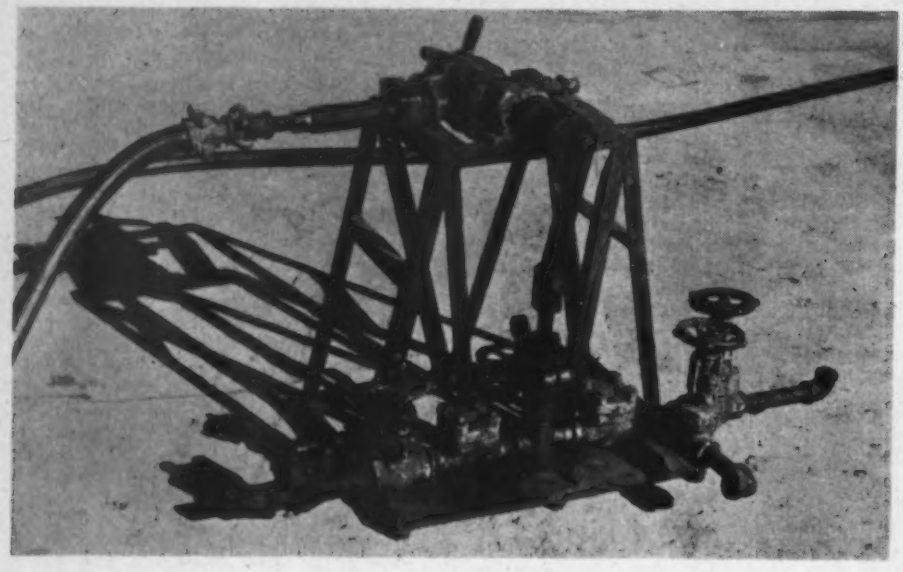
Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,357	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	8,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,876	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,165	224,308	16,529	82,003	6,638	62,609	8,666	57,419
November 29	5,257	5,309	224,540	16,667	86,319	6,382	61,988	8,405	56,747
December 27	5,285	5,543	222,770	17,013	91,269	7,041	50,224	9,698	51,806
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,690	40,580	9,141	50,839
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206

OPERATION HOW TO DO IT MAINTENANCE

HOW TO—
Make Testing Assembly for Pressure Equipment



A COMPACT, air-driven hydrostatic testing assembly for pressure equipment tests is used by Cities Service Refining Corporation's maintenance department in their butadiene plant located at Lake Charles, La.

The pump assembly, which can be fabricated in any plant machine and welding shop, is driven by a small air motor capable of operation at various speeds to afford complete control of pressure application.

Low-pressure water is used for hydrostatic testing purposes. Pressure is elevated to the required level by means of the air driven pump. Check valves serve as pump valves to maintain pressure on the equipment being tested.

Pressure applied can be relieved quickly by opening a relief valve connected to the piston discharge line.

Handy Rack and Storage Bins.

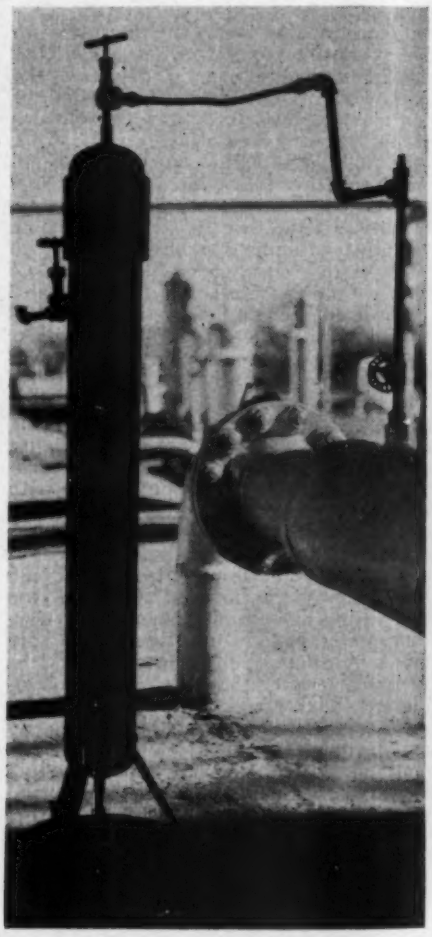
HOW TO—
Make Handy Storage Bin

A CONVENIENT storage rack to hold containers of small fittings, nails, etc., is shown in the accompanying photograph. The rack is all metal and of welded construction and offers considerable storage facilities utilizing a minimum of floor space.

The containers are removable to facilitate replacement of contents.

HOW TO—
Make Inexpensive Gas Sampling Scrubber

WHEN samples of gas are taken frequently for analysis, the test may be affected adversely by condensate or moisture carried mechanically from the header. An inexpensive scrubber is made of 6-inch pipe set on a ring base which sets on the ground or concrete pad



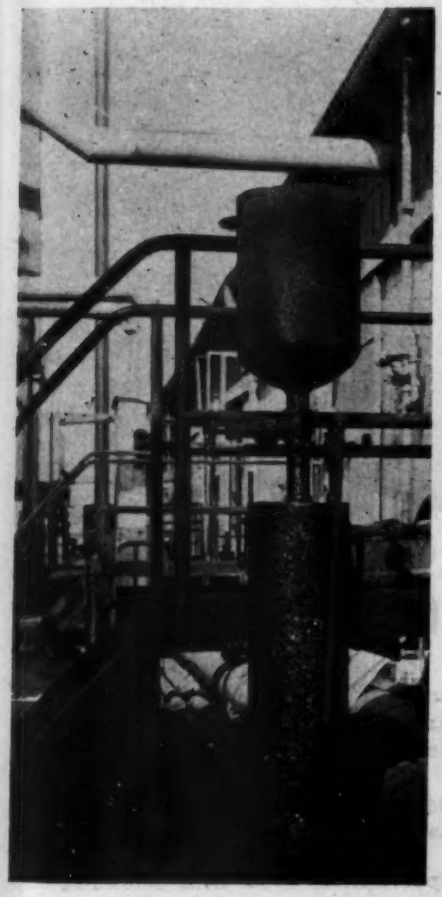
near the pipe line. The top of the scrubber has a collar into which a domed head is fitted. This can be removed for inspection of the interior that may be filled with steel wool, Raschig rings, or any of the commercial drying agents used to remove moisture and condensate from gas. The line carrying the gas from the header is connected to the scrubber with a copper or brass line with universal fittings, to a bar stock valve attached to a line which extends downward into the scrubber with the open end below the packing or scrubber filling. Gas to the sampling container is withdrawn from a connection near the

top of the scrubber so that clean, dry gas is always available for testing. Liquids which may accumulate in the scrubber are withdrawn from a bleeder in the lower head.

HOW TO—

Arrange Waste Cleaning Solvent Disposal

WHERE engines and compressors are wiped daily with cloths wet with solvent to dissolve oils and greases, the waste material is disposed of safely and profitably, by pouring the residue into a blow-case to return the solvent to a slop tank from which it is taken to be rerun and converted into a saleable product. The blow-case is made of a nipple of large pipe having flat heads mounted near a convenient door and entrance walk at



the engine room. A two inch pipe line connected to the base of the blow-case, fitted with a block valve, leads to the slop tank in the plant. A 2-inch pipe in the top of the case supports a gate valve and a large funnel into which the slops are poured from the wash pails. A vent line and a pressure line complete the connections.

"Coin Your Idea"

Contributions (with photos or sketches) to this "How To Do It" Department are invited.

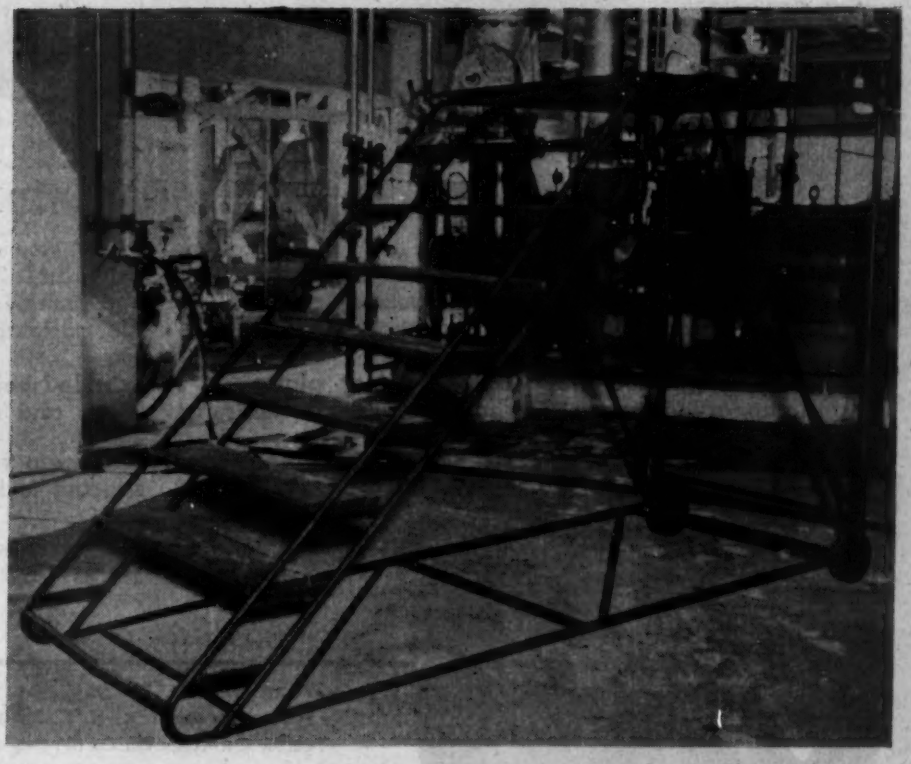
HOW TO—

Install Auxiliary Drip For Instrument Air

CLEAN, dry air can be fed to the recording instruments controlling the action of fractionating and stabilizing columns effectively at low installation cost by using a horizontal 2-inch drip set below the conventional air scrubbbers connected to the instruments. The instruments in this installation are mounted on a board supported by a structural steel frame set on foot pads resting on a concrete pier to insure permanent alignment. Near the base of the vertical channel steel posts of the frame, two inch straps of steel are welded horizontally, extending behind the setting, to which the 2-inch drip is permanently welded. Air enters the drip through a connection on top of the drip at one end, and dry air is fed to the instruments through connections on the top side of the drip. A bleeder at the opposite end, welded to the lower side of the drip is opened frequently as a test for trapped condensate.

HOW TO—

Facilitate Above-Grade Maintenance Operations



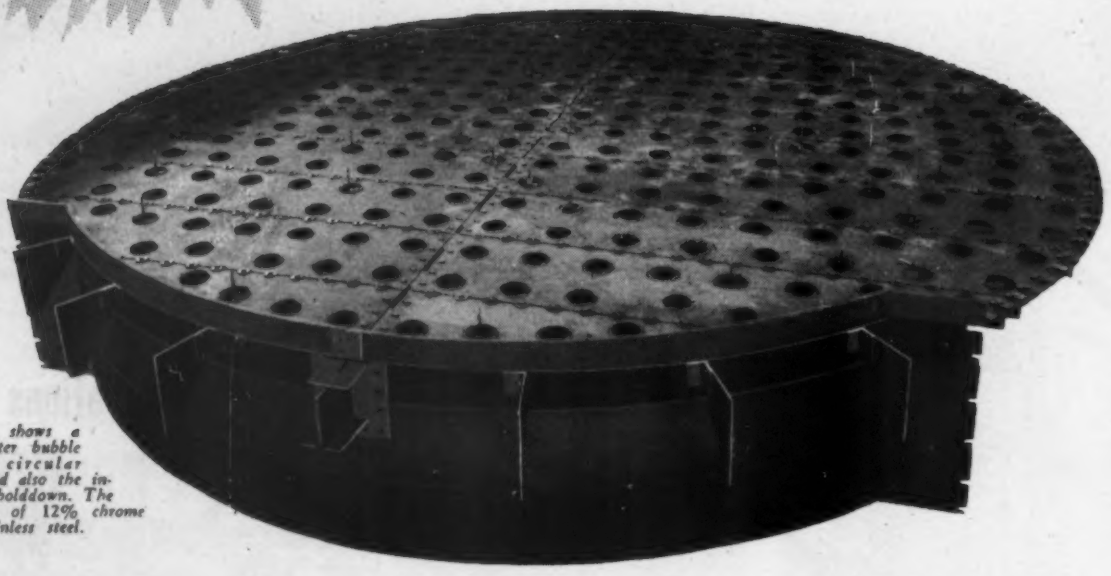
ADEQUATE working space for many above-grade maintenance operations is provided by a lightweight movable platform.

At Cities Service Refining Corporation's butadiene plant at Lake Charles, La., the platform shown was fabricated from standard pipe, angles, small truck wheels, and wood treads and deck.

For ENGINEERED EFFICIENCY

Specify

GLITSCH "Truss Type" Lightweight Stainless Steel BUBBLE TRAYS



This picture shows a 16'-4" diameter bubble tray with circular downcomer and also the individual cap holddown. The tray is made of 12% chrome type 410 stainless steel.

Some of the features engineered into GLITSCH Trays:

1. Fabricated structural major beam for large diameter trays — used with trapezoid minor trusses for maximum rigidity and strength.
2. Thermal expansion joints between deck plates and supporting trusses. No holes to match.
3. Peripheral tray clamps. No holes in tower ring necessary.
4. Individual "snap-in" hold-down frogs for caps and risers. Any type of pressed caps and risers are adaptable to this light weight tray design.
5. Extruded holes in deck plates for "set-on" risers. (Caps and risers not shown in photograph.)
6. Maximum vapor uptake area with extended cap spacing to insure uniform liquid gradient.

MANUFACTURED UNDER U. S. PATENT NO. 2,210,808; NO. 2,309,309; NO. 2,338,926; NO. 2,341,091 AND OTHER PATENTS PENDING

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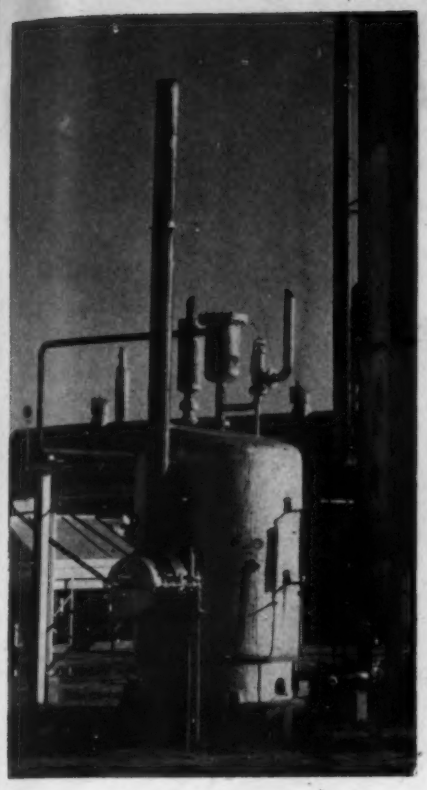
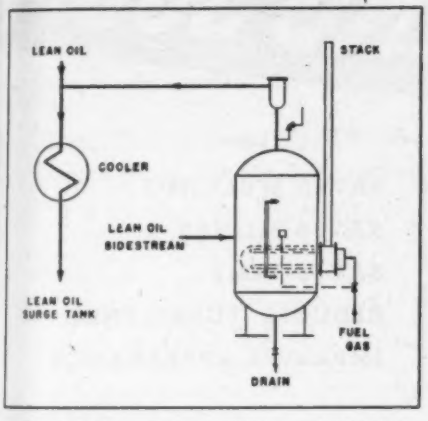
"TRUSS-TYPE" BUBBLE TRAYS ● BUBBLE CAPS ● TOWER INTERNALS





Oil Purifying System, Photo and Sketch.

HOW TO—

Purify Lean Oil In Gasoline Plant

LEAN oil purification in gasoline and cycling plants offers several advantages in operation. Fouling of heat transfer equipment, heat exchangers, preheaters, and oil coolers, is decreased, and the absorption oil returned to the system has a lower molecular weight so that higher operating efficiency is realized.

In one gasoline plant operation, in which the necessary heat for the still and reboilers is obtained from the hot oil, the oil purifying system shown in the diagram and photograph has been used with satisfactory results. The unit has a capacity of several barrels of oil and is continuous in operation. The gas burner is under automatic temperature control to maintain the desired outlet temperature of the vaporized absorption oil.

An internal firebox installed through a flanged opening in the shell is removable for cleaning and repair. A manhole also permits cleaning without removal of the firebox.

As shown in the diagram, a connection is made to the lean oil line from the bottom of the still to the lean oil purifier. Lean oil from the still flows through the lean oil-rich oil exchangers and coolers to the lean oil surge tank. Vapor from the oil purifier is returned to the lean oil stream immediately ahead of the final coolers to the lean oil surge tank. Bottoms from the purifier are dumped into the plant disposal system periodically.

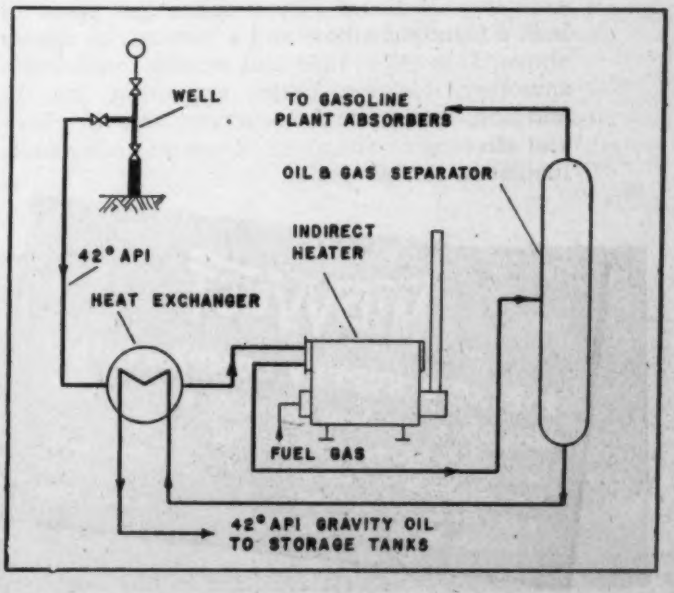
HOW TO—

Increase Plant Yield With Heater-Separator System

THE method used in a low pressure gasoline plant to increase the gpm. content of the inlet gas is shown in the accompanying diagram. In effect, the system is a small crude stabilization unit. The gas to the plant ranges from 12 to 14 million cubic feet daily, and before installation of the crude oil heating system, recovery from separators was approximately 0.5 gallons per thousand cubic feet, or from 6000 to 6500 gallons per day. After installation of the system, production increased to about 13,000 gallons per day.

As shown in the diagram, crude oil from the well flows through a heat exchanger, where it receives heat from the crude oil to storage, and then flows through an indirect heater to the separator. The heater raises the temperature of the oil to 118-120° F. The oil from the separator, which is operated at approximately 30 psig. flows to storage and the gas off the separator to the absorbers of the gasoline plant.

Gravity of the crude oil from the well is about 42.4 °API. After heating and separating, the gravity of the oil to storage is 42 °API. Although higher temperatures would increase the yield of liquid from the gas, the gravity of the "stabilized" crude oil would be lowered below the gravity desired by the operator for marketing reasons. The volume of gas taken from the crude oil by the present method is approximately the amount that would be lost from the oil in the storage tanks.



Sketch of Effective Heat-Separator System

HOW TO—

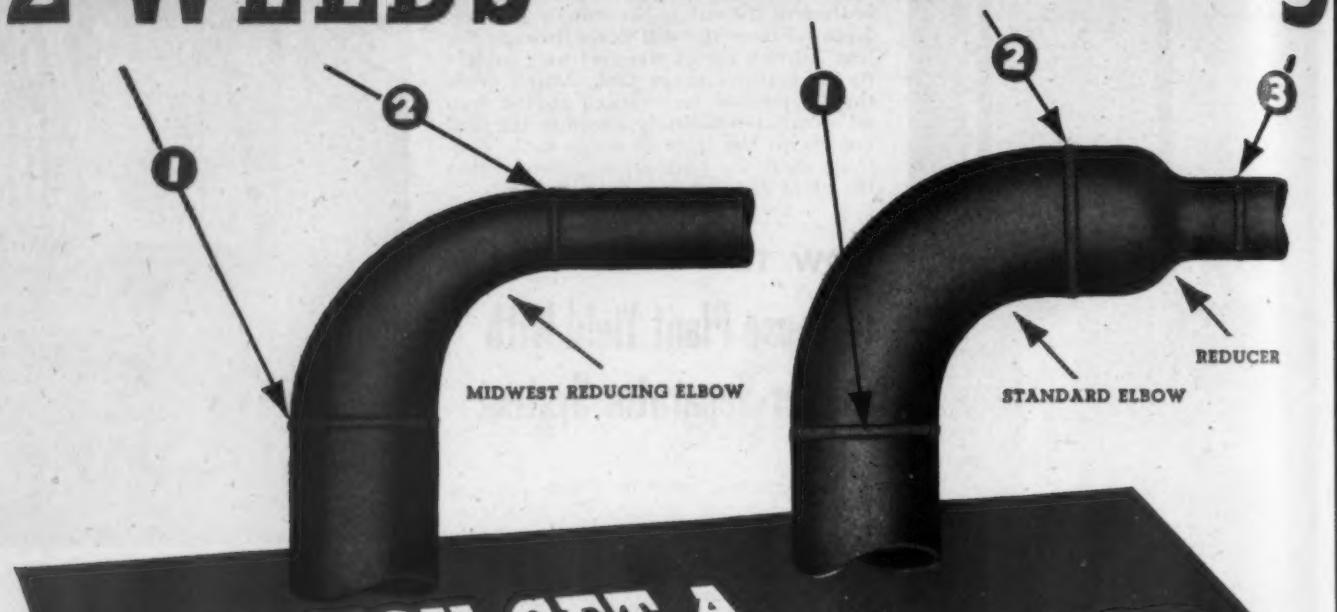
Construct Sound-Proof Telephone Booth

A MOVABLE sound-proof telephone booth for use in refinery areas where there is considerable noise will aid in the relaying of instructions and help prevent misunderstandings.

The booth pictured above was fabricated of plywood and is lined with acoustic fiber blocks. The top is overhanging and the user virtually can inclose himself when talking on the phone. By turning the back side of the booth in the general direction from which the noise emanates a large percent of the noise is blocked and the conversation is quite audible.

Areas wherein the booths are convenient are engine rooms, pump houses, compressor houses, and process areas.

2 WELDS INSTEAD OF 3



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- SAVES TIME
- REDUCES TURBULENCE
- IMPROVES APPEARANCE

One weld is eliminated when the Midwest Reducing Elbow is used to change both direction and pipe size in a welded pipe line . . . you make only two welds instead of three. This exclusive Midwest Fitting takes the place of both a standard elbow and a reducer, as shown above. This saves time and money, produces a smoother, cleaner, better appearing job. In addition, the gradual reduction, smooth curve and absence of abrupt neck reduce turbulence. Insulation is also easier.

All the advantages of Midwest Standard Elbows are to be found in Midwest Reducing Elbows . . . unusual dimensional accuracy, beneficial effect of working metal in compression, stress relieving, etc. Center-to-end dimensions are the same as for standard elbows with which they are interchangeable.

This reducing elbow is one of many Midwest Welding Fittings designed to reduce the cost and improve the quality of welded piping. Write for Bulletin WF-41 for complete information.

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MIDWEST WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS

THE MONTH IN THE INDUSTRY

Rathbone Thinks Refiner Prices Now Not Too High

At the refining level the oil industry has done little more than reflect increased crude prices in the opinion of M. J. Rathbone, president of Esso Standard Oil Company.

The industry in the past year has had its costs increased 2.85 cents per gallon without allowance for higher labor and material costs in the refining division or higher dealer margins, said Rathbone, who gave the following breakdown of the 2.85 figure to the Wolverton committee in Congress: Added costs—2.4 cents due to increased crude price; 0.20 cents due to increased transportation costs; and 0.25 cents due to increased distribution costs. He thought at least another 0.25 cents should be added to cover increase in service station dealers margins.

Rathbone cited figures showing that weighted average price increase of all major fuel products in cargoes at the Gulf in 1947 amounted to only 2.68 cents per gallon, this in face of the fact that crude oil cost refiners 2.4 cents per gallon more at the end of 1947 than in January of the same year.

Rathbone thought that previous refinery prices have been too low and that present ones are not too high.

East Coast Fuel Problem Reported Much Improved

Oil tanker transportation, which throughout this winter has been a bottleneck in moving adequate supplies from the Gulf Coast and Caribbean to the East Coast, has eased greatly through the commissioning of many formerly tied-up Maritime Commission ships and late last month was not an immediate problem so far as the present heating season is concerned.

This was disclosed at a meeting of the Petroleum Regional Advisory Committee for the East Coast. The committee reaffirmed its opinion that, barring severe weather conditions between now and the end of March, and with continued cooperation by the public, consumers' demands would be met throughout the remainder of the heating season.

Telegrams from refiners in the area declared that the additional 3 to 4 million barrels of heating oil and kerosine needed to accomplish that objective would become available.

Leyendecker Leaves Bank, Joins Eastern States

Harry Leyendecker, formerly with Tide Water Associated Oil Company and since 1946 an executive in the Oil and Gas Department of City National Bank, Houston, has become vice president in charge of production for Eastern States Petroleum Company, Houston. He will deal with crude production, development and pipe line problems. He was Tide Water's chief scout and management assistant when he obtained a leave of absence in 1942 to serve with PAW as director of supply and transportation for District 3.

Meetings

March

18-20—Electrical Maintenance Engineers Assn. of Southern California, annual industrial electrical show, Los Angeles Armory.

24-26—Natural Gasoline Association of America, annual convention, Ft. Worth, Texas Hotel.

24-26—API, Mid-Continent Spring Meet, Wichita, Kans., Broadview Hotel.

April

5- 7—Western Petroleum Refiners Association, annual meeting Galveston, Galvez and Buccaneer Hotels.

5- 8—National Association of Corrosion Engineers, annual conference-exhibit, St. Louis, Jefferson Hotel.

13-15—Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.

14-16—API, Southwestern Spring Meet, San Antonio, Plaza Hotel.

19-20—Industrial Accident Prevention Associations, Annual Convention, Toronto, Royal York Hotel.

19-21—American Society of Lubrication Engineers, annual convention, Buffalo, Statler Hotel.

21-23—National Petroleum Association, Cleveland, Hotel Cleveland.

26-27—Independent Petroleum Association of America, Wichita Kans.

28-30—Liquefied Petroleum Gas Association, annual convention, Kansas City.

May

4- 5—American Gas Association, Natural Gas Department, Houston, Rice Hotel.

6- 7—API Pacific Coast Spring Meet, Los Angeles, Biltmore Hotel.

7—American Institute of Chemists annual meeting, New York, Waldorf-Astoria Hotel.

9-12—AIChE Regional Meet, Cleveland, Hollenden Hotel.

10-13—API Division of Refining Mid-Year Meet, Philadelphia, Benjamin Franklin Hotel.

15-22—International Petroleum Exposition, Tulsa.

24-26—American Gas Association, joint production and chemical conference, Asbury Park, N. J., Berkeley-Carteret Hotel.

27-28—Natural Gas & Petroleum Assn. of Canada, Niagara Falls, Ontario, General Brock Hotel.

31—Gas Technology Short Course, Texas A. & I. College, Kingsville.

31—to June 6—Liquefied Petroleum Gas Assn. annual convention and trade show, Sacramento, Calif.

June

2- 4—Annual Short Course in Gas Technology, Texas A. & I. College, Kingsville.

7-11—Pittsburgh International Conference on Surface Reactions, Mellon Institute, Pittsburgh.

21-25—American Society for Testing Materials, annual meeting, Detroit, Book-Cadillac Hotel.

30—to July 2—API, Eastern Spring Meet, White Sulphur Springs, Va., Greenbrier Hotel.

September

13-17—Third Instrument Conference and Exhibit, Philadelphia, Convention Hall.

15-17—National Petroleum Assn. meeting, Atlantic City, Hotel Traymore.

October

4- 9—American Gas Association convention, Atlantic City, Ambassador and other hotels.

11-13—National Lubricating Grease Institute, annual convention, Chicago, Edgewater Beach Hotel.

November

8-11—American Petroleum Institute annual meeting, Chicago, Stevens Hotel.

29—to Dec. 4—18th National Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.

Motor Gasoline Survey Shows Octane Improvement

Reflecting continued improvement in the postwar quality of motor gasoline with respect to octane ratings, the semi-annual survey of motor fuels by the Bureau of Mines showed that the average ratings of premium and regular-price gasolines sold at filling stations during the summer of 1947 were higher than for the two summers preceding.

Filling-station samples collected in 17 marketing areas of the country showed the octane rating of premium-price gasoline sold last summer averaged 79.2, compared with 78.3 the preceding summer, and 74.9 two years before. The average octane rating of regular-price gasoline last summer was 75.1, compared with 74.4 in the summer of 1946, and 69.7 in the summer of 1945.

Results of the semi-annual survey, the 22nd in a series started in 1935 in cooperation with the Coordinating Fuel Research Committee, are contained in the Bureau publication, Report of Investigations 4248, "National Motor-Gasoline Survey, Summer 1947," available from Bureau of Mines, Publications Distribution Section, 4800 Forbes St., Pittsburgh 13.

New Highs for Aruba

Lago Oil and Transport Co., Ltd., an affiliate of Standard Oil Company (New Jersey), hit a new record high in the processing of crude oil in December for the second successive month at its Caribbean refinery at Aruba, Netherlands West Indies. December runs averaged 380,484 barrels per day, compared with November's 375,900 barrels.

The Aruba refinery also achieved a new one-day peak for crude runs, amounting to 434,750 barrels. Previous high for a single day's operations was reached in November with 425,113 barrels.

Hurst to PT&T

Petroleum Trading and Transport Company announced the appointment of Clyde J. Hurst to their staff to succeed H. E. McCormick, resigned. For the past 22 years Hurst has been associated with the Deep Rock Oil Corporation.

Petroleum Trading and Transport Company and Three Rivers Refinery, which engage in the manufacture and marketing of petroleum products, are part of the Boudreau interests which have moved home offices in Tulsa to the Hunt Building.

Association Works On Cost-Reduction Program

A program to reduce and stabilize construction costs in the oil refinery, steel and chemical industries through the advancement of labor-management relations was forwarded last month by the membership of the National Constructors Association at the organization's annual meeting in New York.

Formed a year ago to help create a better understanding between unions in the building and construction trades,

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Shreveport, Louisiana
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Brookhaven, Mississippi
Cut Bank, Montana
Winnett, Montana
Hobbs, New Mexico
Blackwell, Oklahoma
Drumright, Oklahoma
Duncan, Oklahoma
Lindsey, Oklahoma
Oklahoma City, Oklahoma
Seminole, Oklahoma
Alice, Texas
Borger, Texas
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THE MONTH . . .

the 16 companies included in the association's membership and their clients in the oil refinery, steel and chemical industries, the organization has become a forceful spokesman in labor and construction circles, G. F. Bayes, president, said in his annual report.

The principal work, according to Bayes, has been to bring together the three elements that produce new industrial facilities—labor, builders and owners—in an effort to devise ways to reduce and stabilize spiraling building costs.

Association offices are at 277 Broadway, New York and C. B. Bronson is secretary-treasurer. Included in the membership are 16 companies which build on a national basis in the oil, steel and chemical fields, and the combined volume of work on their books approaches $1 billion.

Colburn Finishes Course For Humble at Baytown

Dr. Allan P. Colburn, assistant to the president and advisor on research at the University of Delaware, last month completed a two-week's series of lectures on "Advanced Topics in Distillation" for technical and research personnel at Humble Oil & Refining Company's Baytown, Texas, refinery.

The course is another in the "Humble Lectures in Science" series, designed to keep refinery personnel abreast of latest scientific developments. The series is now in its second year. Lectures remaining on this year's schedule are Dr. Richard T. Arnold, professor of chemistry at the University of Minnesota, and Dr. Joel H. Hildebrand, professor of chemistry at the University of California. Lecture courses are attended on a full-time basis.

Dr. Colburn's course was devoted largely to new horizons in azeotropic and extractive distillation to aid Humble researchers in developing new techniques.

Lovell Joins Ethyl As Associate in Research

Wheeler G. Lovell, for 21 years assistant head of the organic chemistry department of the General Motors Research Laboratories, has joined Ethyl Corporation's Research Laboratories, Detroit, as an associate director of research in the basic combustion field.

Lovell, a graduate of both Harvard and Massachusetts Institute of Technology when with General Motors served with T. A. Boyd, who was a coworker of the late Thomas Midgley, Jr., in the research program in which the antiknock properties of tetraethyl lead were discovered. He is the author of many technical papers covering many fields of interest pertaining to the fuel-engine relationship.

Texaco Grant to MIT To Study Atomic Power

A $250,000-grant for atomic research and training of nuclear scientists has been made to the Massachusetts Institute of Technology by The Texas Company. The funds will be used for long-range pure research in nuclear fission and related basic studies on the ultimate nature of matter and energy, to construct high voltage equipment of advanced design, and to train scientists in nuclear theory and its application.

The grant "is an outstanding example of the ever-widening range of industrial interest in the advancement of fundamental knowledge," Institute officials said. It constitutes an enlightened form of investment in progress, contributing not only to the development of new processes and new products, but to the education of young scientists and engineers."

Low Is Superintendent

Allan W. Low has been named general superintendent of a new formaldehyde plant of Monsanto Chemical Company's Plastics Division. Low has been employed by the General Chemical Division of Allied Chemical and Dye Corporation in manufacturing research and administrative capacities for the past 12 years.

Thick Aluminum Welded

The successful welding of thick aluminum plate at Battelle Institute, Columbus 1, Ohio, and at other laboratories and fabricating plants, will expedite plans for the production of gasoline from natural gas and oxygen.

The welding of thick aluminum plate makes feasible the use of this metal in the construction of plants for the production of liquid oxygen.

Battelle technologists have been working on the development of satisfactory techniques for welding thick aluminum in a research investigation sponsored by the Stacey Brothers Gas Construction Company. Among the applicable welding processes which have been used successfully is the argon-shielded tungsten-arc process. The welder in the photograph is joining two 2½-inch slabs of aluminum allow using this process.

Alkanes and Alkenes Treated in Monograph

The Michigan State College Press, East Lansing, Mich., has published, "A Correlation of Some Physical Properties of Alkanes and Alkenes", by Ralph Chase Huston, Ph.D., Sc.D., dean of the School of Graduate Studies and professor of organic chemistry, Michigan State College.

This monograph presents a theoretical discussion of: a) The dependence of the boiling points of isomeric alkanes and alkenes upon their relative energy contents and coordinations; b) Molecular volumes as composite functions of cohesions and the relative contact areas of the molecules; and c) Surface tensions, as measures of cohesions in the surface films, an their relationships to boiling points and densities.

Bound in cloth with index, graphs, etc., the monograph sells for $1.75.

Shea Rejoins Esso After Three Years With Carter

Paul C. Shea, former vice president and a director of The Carter Oil Company, Esso affiliate, has been named assistant to the general manager of the supply and transportation department of Esso Standard Oil Company, effective February 1.

Shea, an Esso man since 1926 when he began work at the Everett refinery, was a technical assistant to the vice president of Colonial Beacon Oil Company and later was named a vice president and refinery general manager at Everett. He went to Carter on a loan basis in 1945 when he was made acting manager of manufacturing of its Northwest division.

New Set-Up for Industry Public Relations Program

The oil industry's public relations program, initiated a year ago, was organized early last month for the coming year with the election of Ralph Champlin, of Ethyl Corporation, as chairman of the supervising committee, the name of which committee was changed to "Oil Industry Information Committee." Heretofore it was known as the "Public Relations Operating Committee."

Champlin, who is director of public relations for Ethyl Corporation, succeeds. Franklyn Waltman, director of public relations for Sun Oil Company.

The committee voted to change its selection of vice chairmen to a functional basis instead of the geographic basis used last year. Thus, four vice chairmen were named, each in charge of a special phase of the program as follows: H. L. Curtis, Shell Oil Company, advertising; W. R. Huber, Gulf Oil Corporation, supply-demand conservation program; George Freyermuth, Standard Oil Company (New Jersey), general publicity; Conger Reynolds, Standard Oil Company (Indiana), industry relations.

Under the new set-up the committee will supervise the work of the informational services of the American Petroleum Institute in addition to managing the industry-wide program, William R. Boyd, Jr., president of the Institute, announced.

Formal recognition of current oil industry problems was given by the com-

THE MONTH . . .

mittee which said the current program is devoted to the supply and demand situation in affected areas.

A more realistic statement of the objectives of the industry's information program included efforts to obtain better public understanding of:

1) How the oil industry is building new facilities and working to meet America's ever-increasing use of petroleum products.

2) How the consumer can take full advantage of the utility and economy of petroleum products by using them wisely and efficiently.

3) How competition in the oil industry results in constantly improved products, higher standards of service and ever-increasing supplies at reasonable prices.

The program's long range objectives remain unchanged, it was stated.

The committee authorized a quick survey of public opinion to determine what questions are now foremost in the public's mind regarding industry behavior.

Short Course Program

The program in final form for the Southwestern Gas Measurement Short Course, April 13-15, University of Oklahome, Norman, will be ready for mailing shortly, according to General Chairman E. C. McAninch, Oklahoma Natural Gas Company, Ardmore. The general committee at its January meeting selected 60 persons to conduct the diversified classes. C. E. Terrell, Southern Natural Gas Company, Birmingham, Ala., is chairman of the program committee.

Mellett Vice President

Dana S. Mellett, chief engineer of the Trenton (Mich.) refinery of Socony-Vacuum Oil Company, Inc., has been appointed vice president of Mediterranean Refining Company. E. A. Wilson has been appointed chief engineer to succeed Mellett.

Floyd Martin Named Sunray Executive Vice President

Floyd L. Martin has been named executive vice president of Sunray Oil Corporation. He will continue his responsibility as vice president directing the company's refining and sales division. Martin has been a vice president since 1935, and a director since 1941.

Martin

He joined Sunray in 1930 after having served a refining apprenticeship in Oklahoma at Jennings, Allen, Sand Springs, Tulsa, and Ponca City. His first post was at Allen, Okla. He took over the former Bell Oil and Refining Company, Santa Maria, Calif., plant for Sunray in 1946 and on August 31 of last year he took charge of Sunray's newly purchased, war built refinery at Duncan, Okla.

ACS Sections Select Officers for the Year

American Chemical Society section elections reported last month included:

Dr. Sherman S. Shaffer, head of the experimental and testing division of Humble Oil & Refining Company, Baytown, Texas, named chairman of the Southeastern Texas division succeeding Briggs B. Manuel of W. H. Curtin & Company, Houston, who was named to the national council.

Dr. W. O. Milligan, professor of chemistry in Rice Institute, Houston, was chosen chairman-elect and W. R. White of the Hughes Tool Company, Houston, secretary-treasurer. Preston L. Brandt of Pan-American Refining Company, Texas City, and Jack L. Battle of Humble were selected with Manuel to serve on the national council.

Named as chairman of the Baton Rouge section ACS was C. E. Starr, Jr., assistant director of the Esso laboratories of Esso Standard Oil Company, Baton Rouge.

He succeeds Robert S. Asbury, assistant manager of the development section of Ethyl Corporation's Baton Rouge plant.

Other officers include: Dr. Philip W. West, associate professor of chemistry in Louisiana State University, chairman-elect; Dr. C. Truman Steele of the petroleum technical service department, Baton Rouge refinery, Esso Standard Oil, secretary; and Dr. Arthur L. LeRosen, assistant professor of chemistry, LSU, treasurer. Dr. W. Rigeley Edwards, Jr., professor of chemistry in LSU, and Dr. George F. Kirby, Jr., of Ethyl, were named to the National Council.

John S. Ball, senior refinery engineer in the Petroleum and Oil Shale Experiment Station of the Bureau of Mines, Laramie, Wyo., has been elected chairman of the Wyoming Section. He succeeds Professor Ernest R. Schierz, head of the chemistry department of the University of Wyoming.

Other new officers are: Dr. Henry G. Fisk, director of the University's Natural Resources Research Institute, chairman-elect; Dr. J. Thomas Field, professor of chemistry in the university, secretary; and L. E. Walter, state chemist, treasurer. Elected to the Society's National Council was Dr. F. C. Freytag, professor of chemistry in the university.

Bolte Leaves Institute to Join Battenfeld Grease

Carl E. Bolte, executive secretary since July, 1946, of the National Lubricating Grease Institute, on January 1, 1948, became vice president in charge of sales of Battenfeld Grease & Oil Corporation, Kansas City, Mo. NLGI headquarters staff will carry on the Institute's work until Bolte's successor is named, it was announced.

Fellowships Offered

Three one-year $1000 fellowships for graduate study in engineering and science at the Carnegie Institute of Technology, Pittsburgh, for the academic year 1948-49, are to be awarded by the Matthes Foundation, New York, to any Latin American students. Deadline for the filing of applications is April 15, 1948.

Andrews Leaves Phillips, Joins Sid Richardson

Appointment of Frank Andrews as sales manager for Sid Richardson Carbon Company of Odessa, Texas, was announced last month by Sid W. Richardson.

Andrews

Andrews had been with Phillips Petroleum Company for the past 19 years as manager of Phillips' chemical products department and is liquefied gas, solvents, rubber and carbon black industries. His original expereince with Phillips Petroleum Company, starting in 1929, was in the liquefied gas field. In 1940 he organized the sales department for Hycar Chemical Company; in 1943 he started the marketing division for Phillips furnace black, and later, became manager of their chemical products department, where he became associated with the solvents market.

In his new post he will headquarter in Fort Worth, Texas.

Lion Oil Buys Chemical Plant at El Dorado

Lion Oil Company has purchased from the United States government the chemical plant near El Dorado, Ark., formerly known as Ozark Ordnance Works, and one of the largest U. S. producers of anhydrous ammonia, ammonium nitrate fertilizer, and nitrogen fertilizer solutions.

From May, 1943, until May, 1946, Lion Oil Company, through a wholly-owned subsidiary, operated this plant on a cost-plus-fixed-fee basis. In May, 1946, Lion took over the plant for private operation under a long-term lease and has been operating it continuously.

New Technologists Group Is Formed by Monsanto

A senior technologists group has been formed in the process section of Monsanto Chemical Company's general engineering department, the purpose being to provide specialized technical aid to all divisions and departments of the company. Directed by J. M. Graham, Jr., four men have been named to the group as follows: Hart U. Fisher, instrument technologist; Alban J. Lobdell and Robert York, Jr., chemical engineering technologists; and Frank LeRoy Whitney, Jr., corrosion technologist.

California Standard Elects Two New Directors

New directors were elected by Standard Oil Company of California last month as two directors retired from active service.

One new director, also appointed a vice president, is Hillyer Brown, San Francisco attorney.

The other director, named previously, is Gage Lund, chairman of the board of The California Company and Standard Oil Company of Texas, both wholly

BRIDGEPORT'S CONDENSER TUBE ALLOYS
WITHSTAND A WIDE VARIETY OF CORROSIVE CONDITIONS

The term "corrosion" covers a host of ills, any one of which may impair or result in shutdown of heat exchanger equipment. The cure depends upon a correct diagnosis of the factors influencing corrosion and the selection of the *right* condenser tube alloy.

Bridgeport offers its extensive experience and laboratory facilities to assist you in solving your corrosion problems. Listed below are various gases, acids, salt solutions, etc., and the copper-base alloy tubes which are successfully used for handling them.

HYDROCARBONS . . . In the purified form, liquid hydrocarbons are virtually non-corrosive to all copper alloys. This is also true of such gases as butane and propane. Where sulphur compounds are present in these products, alloys with lower copper content are generally more satisfactory, i.e. Muntz Metal, Naval Brass, and Admiralty.

ACETIC ACID . . . Copper has been widely used for handling acetic acid and acetates. However, under certain conditions, 70-30 Cupro Nickel has been found even more satisfactory.

ALCOHOLS, GLYCOLS, AND ESTERS . . . Are handled very satisfactorily by copper, Duronze IV (No. 53 aluminum bronze), Aluminum Brass, Admiralty, etc.

GASES . . . Fluorine, Freon, hydrogen, nitrogen and oxygen have been handled satisfactorily by Copper, Aluminum Brass, Admiralty, 70-30 Cupro Nickel, etc., at atmospheric temperatures.

HALOGEN DERIVATIVES—(chlorinated organic compounds) . . . In the absence of moisture, these are handled successfully by all copper-base alloys. In the presence of moisture, increased corrosion may be encountered. No. 632 Silicon Bronze, No. 609 Silicon Bronze, Red Brass, etc., are preferred.

HYDROFLUORIC ACID . . . 70-30 Cupro Nickel has shown good corrosion resistance to aqueous hydrofluoric acid solutions and anhydrous hydrogen fluoride.

SALT SOLUTIONS . . . Non-oxidizing salt solutions are generally handled very satisfactorily by copper and copper-base alloys. Where the velocity is high, such alloys as Duronze IV (No. 53 aluminum bronze, 95% copper, 5% aluminum), 70-30 Cupro Nickel and Aluminum Brass, are preferred.

SODIUM HYDROXIDE . . . In the absence of sulphides, 70-30 Cupro Nickel shows excellent resistance to sodium hydroxide.

SULPHURIC ACID . . . Copper-base alloys show good corrosion resistance to sulphuric acid and phosphoric acid, in the absence of oxidizing agents such as dissolved oxygen, ferric sulphate and sodium dichromate. In such applications, the Silicon Bronzes No. 632 and No. 609 show maximum corrosion resistance.

**U. S. Pat. No. 2,093,380 **U. S. Pat. No. 2,118,688*

DURONZE IV* (aluminum bronze)—exceptionally resistant to hot brine; polluted sea and brackish water, and gives fine service against corrosive liquids in many processing industries.

CUPRO NICKEL—Used for handling caustic and other alkaline liquids, salt solutions, sea water and numerous gases.

CUZINAL (aluminum brass)—especially suited for marine installations where aerated sea water is circulating medium, since it offers high resistance to air impingement corrosion.

ARSENICAL ADMIRALTY—widely used for handling sea water or polluted fresh water, hydrocarbon gases containing sulphur compounds; gasoline, lubricating oils, etc.

ARSENICAL MUNTZ**—has high resistance to sulphur attack as well as to dezincification from corrosive fresh or saline waters. Effective for handling sulphur-bearing oils and gases.

DUPLEX TUBING—for double corrosive conditions—widely used in ammonia refrigeration and in the processing of a variety of chemicals.

"Bridgeport" BRASS CO.

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONN. • *Established 1865*
Mills at Bridgeport, Connecticut, and Indianapolis, Indiana
In Canada—Noranda Copper and Brass Limited, Montreal

Condenser and Heat Exchanger Tubing
BRIDGEPORT BRASS

owned subsidiaries of Standard of California.

Retiring as vice presidents and directors are J. L. Hanna and J. H. MacGaregill.

Standard also announced appointment of Paul L. Fahrney as a vice president and Marshall Madison as its general counsel.

After joining Standard in 1911, Hanna held a variety of positions with increasing responsibilities at the El Segundo, Bakersfield and Richmond refineries, and became general manager of all refinery operations in 1933. Of recent years, among other duties, he has directed activities of Standard's tanker fleet.

Gulf Said to Be Planning Venezuela, Domestic Plants

Plans are said to have been drawn up by Gulf Oil Corporation for a refinery in Venezuela with talk, without confirmation, that the company also will build a $40 million refinery on Staten Island in New York harbor on land already owned by the company. If the Staten Island project materializes, it likely will be designed to handle Middle East as well as domestic crudes.

Tyneside Plant Approved

The British government and Tynemouth Corporation have given approval of the new Tyneside refinery proposed by Trent Oil Products Development Company, Ltd., near North Shields. It is hoped to begin construction work early this year on a full crude refining plant costing between $4 and $8 million.

An input capacity of 4,250,000 barrels a year (11,500 barrels daily) is envisaged, but it has not yet been decided whether lubricating oils are to be produced. Harold Moore is in charge of design.

Sid Richardson Plant

Sid Richardson Gasoline Company is constructing a large natural gasoline plant in the Keystone Field near Kermit, Texas. When completed the plant will have a daily production of about 86,000 gallons of propane and butane and 120,000 gallons of natural gasoline. This latter product will eventually be separated into a wide range of close-cut solvents that can be used in the rubber, paint and other industries.

The Sid Richardson refinery in Texas City is now producing some of these products and the facilities there also will be enlarged to furnish additional types that may be required, officials said last month.

Texas A. & I. Short Course

Emphasizing gas turbine design, the Third Annual Short Course in Gas Technology will be conducted June 2-4 at the Texas College of Arts and Industries, Kingsville. The meeting is sponsored by the Southern Gas Association.

Sections will be offered on "Improved Techniques in the Utilization of Natural Gas" and on "Latest Methods for Solving Important Problems of Production and Transmission."

The administrative committee is headed by Dr. Frank H. Dotterweich, A. & I. engineering division director.

Sinclair Research Construction Progressing

Principal buildings for Sinclair Refining Company's research and development laboratory are shown above rapidly approaching completion on the 38-acre site at Harvey, Ill. The Austin Company holds a $4 million contract covering design and construction.

The three-story administration building, can be seen on the left, beyond the parking lot, and is directly connected to the "U"-shaped main laboratory building. The tall structure in foreground just left of center will house six individual pilot plant units, which are separated from each other by corrugated aluminum partitions. A network of pipe lines connects this central pilot plants building directly to the tanks and pump house, adjacent to cooling towers in the lower left corner.

Boiler house and shop building are directly beyond the pilot plants, and between them and the administration building, are the clock house, change house and dispensary. The other two completed buildings serve as distillation, compounding and lube testing laboratory (right), and as a catalyst activity laboratory (left).

Compounding and Grease Plant Seen for Chicago

Cities Service Oil Company is to build a compounding and grease plant in the Chicago metropolitan area at a cost of $2.5 million, it was announced last month. Between 5 and 7 million pounds of grease and some 16 million gallons of lubricating oil will be turned out annually. Besides the plant there will be docks for barge, rail and truck transportation, a laboratory, office and other facilities. Completion by mid-1949 is planned.

The plant will obtain its blending stocks from the solvent lube plant now being build by Citcon Oil Corporation at Lake Charles, La.

Phillips Petroleum Lists Hansford County Plant

Plans for the construction of a gasoline plant in Hansford County, Texas, has been announced by Phillips Petroleum Company.

The plant will have an initial daily capacity of 173 million cubic feet of gas with an ultimate output of 343,000 Mcf. It also will produce 54,000 gallons of gasoline and 52,000 gallons of liquefied petroleum gas.

The natural gas resulting from the plant will be pipelined through the Michigan-Wisconsin pipe line to serve the Detroit area.

New Asphalt Plant

Standard Oil Company of British Columbia, Ltd., will erect a new asphalt plant costing some $500,000 near the company's Stanovan refinery on the south shore of Burrard Inlet in Burnaby, near Vancouver. Providing facilities for the manufacturer, blending and shipping of asphalt and cut-back asphalts, the new plant is scheduled to go into operation early next month. The unit, which will substantially increase the total refinery capacity, will have a daily capacity of about 175 tons of finished products.

Republic Will Repair Plant Bought from WAA

Republic Oil Refining Company, Texas City, Texas, has bought from WAA the wartime gasoline plant which Republic operated, the purchase price being $2.3 million. Republic will spend $250,000 in six months for repair, restoration and rehabilitation. Included in the sale are 16.8 acres of land and 32 reinforced concrete steel buildings.

Co-op Buys Pana Plant

Illinois Farm Supply Company, oil cooperative affiliate of the Illinois Agricultural Association, has purchased the Pana Refining Company 4000-barrel plant at Pana, Ill., in a move intended "to improve the supply position" of the co-op, it was explained.

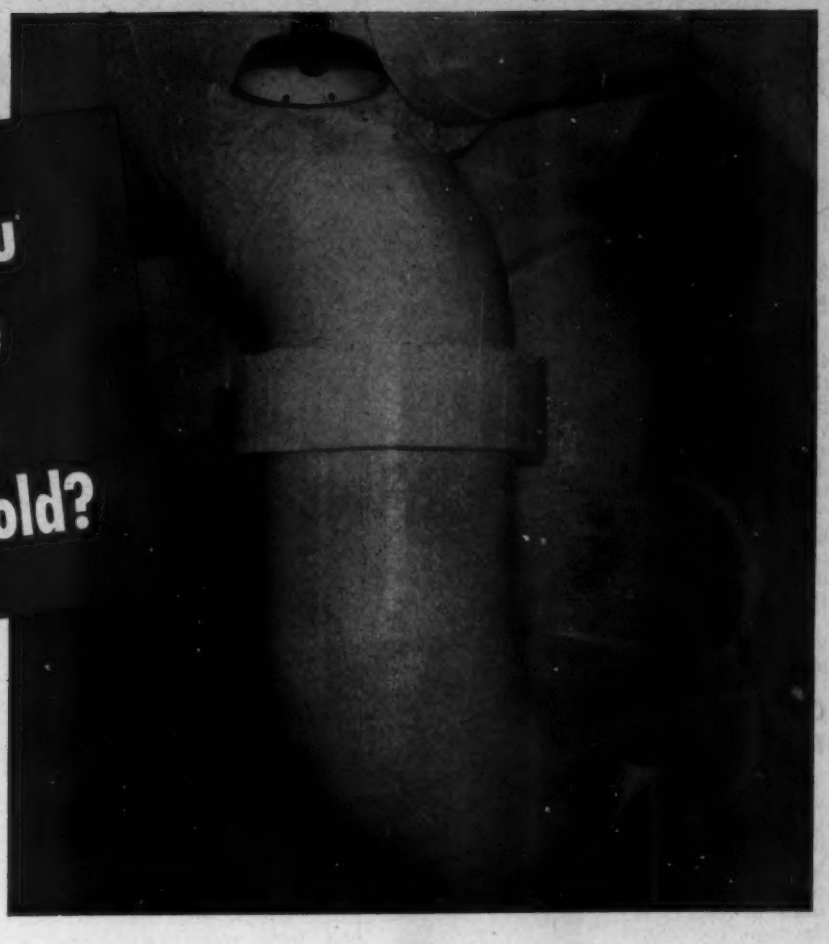
The original announcement said that E. G. Youngberg would remain as general manager of the Pana refinery.

Plant for Kansas

Application for construction of a natural gasoline plant in Granty County, Kansas, near Ulysses has been made by Magnolia Petroleum Company.

The proposed plant would have a

How would you insulate a line that delivers both heat and cold?



HERE'S THE PROBLEM: A piping system carries air to test airplane carburetors. For weeks the air is heated to 200° F. For somewhat shorter periods the same line delivers air at 75° below zero. What covering for the pipes will hold both these temperatures economically?

☐ 9" Cork covering or lagging

☐ 3" 85% Magnesia and 6" cork lagging

☐ Standard Thick Magnesia and 7" cork lagging

Here's what the Armstrong Engineer recommended:

The first suggestion—9" cork covering—would be excellent for the low-temperature phase of the operation. But the 200° F. heat would eventually cause the cork to shrink and crumble. It is never used for temperatures over 150° F.

The second suggestion, 3" of Magnesia and 6" of cork, would provide sufficient insulation to permit economical operation of the line. However, three inches of magnesia is more than is required to reduce temperatures to within practical limits for the outer layer of cork when the line is operating at 200° F. Also, it would not take full advantage of the higher insulating efficiency of cork.

The third suggestion, Standard Thick Magnesia and 7" of cork lagging, is the most practical and economical specification for this line. Standard Thick Magnesia is sufficient to bring the temperature at the cork below 150° F. Over the Magnesia, 7" of cork lagging will provide adequate insulation to maintain the 75° below zero temperature for the length of time required on this job. And the cork lagging can be tightly sealed to prevent damaging vapor penetration when the line is operating at low temperatures.

An unusual problem like this cannot, of course, be solved by any simple rule of thumb. Dozens of factors must be analyzed and provided for. Armstrong's engineers are qualified by training and experience to give you the right answer. That's why it pays you to talk over your insulation problems with an Armstrong engineer. He can furnish expert advice, as well as the right materials and skilled workmen for applying them.

FREE! INSULATION CHECK LIST

This chart lists types and thicknesses of insulation for temperatures from 300° below zero to 2800° F. Write today to Armstrong Cork Co., Industrial Insulation Department, 7503 Maple Ave., Lancaster, Pennsylvania.

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Complete Contract Service For All Temperatures

From 300° Below Zero

To 2800° Fahrenheit

THE MONTH...

daily intake of 100 million cubic feet of gas with an estimated recovery of 19,000 gallons of natural gasoline and 15,000 gallons of 130-pound vapor pressure LPG a day.

Humble Expansion Includes New Pipe Still at Baytown

Humble Oil & Refining Company will start a $19 million expansion program this year at their Baytown, Texas, refinery, the major item being a new pipe still which will enable the plant to run an additional 45,000 barrels of crude daily. This is nearly 20 percent more than its current volume.

A new plant for the manufacture of a greater quantity of lube oils is almost completed. Construction also will get under way in 1948 on modernization of the plant's mechanical shops.

A $2 million addition to Humble's gasoline plant located at Kilgore, Texas, is also in progress.

Carl Miller Is Added To Staff at Battelle

As part of its expanded fuels and combustion research, Battelle Institute, Columbus, Ohio, has named Carl E. Miller to its research advisory staff. Miller, key man in the Army's wartime fuel conservation program, will act as a technical advisor on research in coal, gas, and petroleum technology.

Miller

For eight years Miller was with Potomac Electric Power Company, Washington, D. C., and for three years with Northern Indiana Public Service Company, Michigan City, Ind. During the war, he served with the War Department in the office of the chief of engineers. He is a graduate in electrical engineering from the University of Cincinnati and also has studied at Northwestern University. He is author of numerous articles on fuels technology. While with the War Department, he directed the publication of manuals on fuels and on the operation and maintenance of boiler and heating plants.

SCMA Speakers

Frank G. Philo, chief mechanical engineer of Southern California Edison Company, Los Angeles, will be the principal speaker on the March 18 program of the Southern California Meter Association. His talk will be "Automatic Control" and its application in this new power station.

Harold Nickle of Precision Instrument Company, Long Beach, will present "Special Instruments and Their Applications."

NLGI Convention

The National Lubricating Grease Institute has chosen the Edgewater Beach Hotel, Chicago, as the place and October 11-13 as the dates of its 16th annual convention.

Licensing of Hydrocol Proccess to Other Oil Companies Announced as Texaco Policy

The Hydrocol process for manufacture of synthetic gasolines can now be licensed to anyone within the petroleum industry, W. M. Stratford, president of Texaco Development Corporation announced last month.

This process, which resulted from the joint and continuing research efforts of Hydrocarbon Research, Inc., and The Texas Company, will go into operation on a large commercial scale early in 1949 at the Hydrocol plant at Brownsville, Texas and at the Stanolind plant at Hugoton, Kan. Each of these plants, when completed will produce in excess of 7000 barrels of synthetic gasoline daily.

L. C. Kemp, Jr., director of research for The Texas Company, announced that a new research center and pilot plants have been established at Montebello, Calif., for the further development of processes for manufacturing of synthetic products from varied sources of supply. Semi-commercial scale pilot plants at Montebello, capable of producing 5000 gallons of synthetic gasoline per day, are now operating, Kemp said.

Pilot Plants Completed

Although basic development work on the new process has been carried on for the past two years, permanent buildings and the new pilot unit structures have just been completed. Work is under way on the conversion of heavy fuel oils and of various types of coal to synthetic fuel.

"The Texas Co. has been doing research and development work in this field for more than ten years, and the making of synthetic fuels has become of major significance, involving more than one fourth of the Company's entire research program," Kemp declared. "Currently, some 12 pilot units are being operated on various phases of the expanding project. These range from small 'bench model' units at the company's center for fundamental research at Beacon, N. Y., to the large semi-commercial units at Montebello.

"Results of development work done by Texaco and others are such that the modern synthesis process bears little resemblance to the old Fischer-Tropsch process. As a result of greatly increased throughputs, cheaper and better catalysts and improved conversions and yields, investment costs for a given production capacity are approximately one third those for the German process. Over-all costs of making gasoline by the new process are about one fourth that of the Fischer-Tropsch method. The new process has reduced costs to a point at which synthetic gasoline can be competitive with fuel made from petroleum by modern refinery procedures."

50 Plants in Ten Years

Kemp stated that the new process produces a high quality gasoline with an octane rating of 80 and higher—as contrasted with the old process which gave products with a rating of 20 or lower and which required extensive processing before they were usable in internal combustion engines.

Stratford was quoted by the Associated Press as saying that several companies are now considering building hydrocol process plants and in the same article Kemp is quoted as predicting that "within 10 years 50 such plants may be operating to provide 350,000 barrels of gasoline daily."

Shell Chemical's Read Succeeds S. S. Lawrence

Sidney S. Lawrence, for 18 years sales manager of Shell Chemical Corporation, retired on February 16.

Lawrence's Shell Chemical career began while plans for the company's first plant were still in the blueprint stage. He helped choose the plant site and was sales manager when operations began in 1931.

The position of sales manager of Shell Chemical's Western Division, will be filled by Barclay K. Read, formerly assistant sales manager. Before joining the Shell staff in San Francisco, Read was assistant Sales Manager of the company's Eastern Division, New York.

Arthur D. Little, Inc., Names Morss a Director

Everett Morss, president of Simplex Wire and Cable Company, has been elected to the board of directors of Arthur D. Little, Inc., Cambridge, Mass., industrial research organization. Morss replaces as director, Governor W. Cameron Forbes, who resigned after 25 years on the board.

In his annual report, President E. P. Stevenson, President of Arthur D. Little, Inc., stated that the organization now parallels closely in its diversity the pattern of industrial research as a whole in the United States. He referred particularly to two developments in 1947, the Collins helium cryostat and the operation of pig-iron blast furnaces under pressure.

Leaders Expound Different Views on Stockpiling Oil

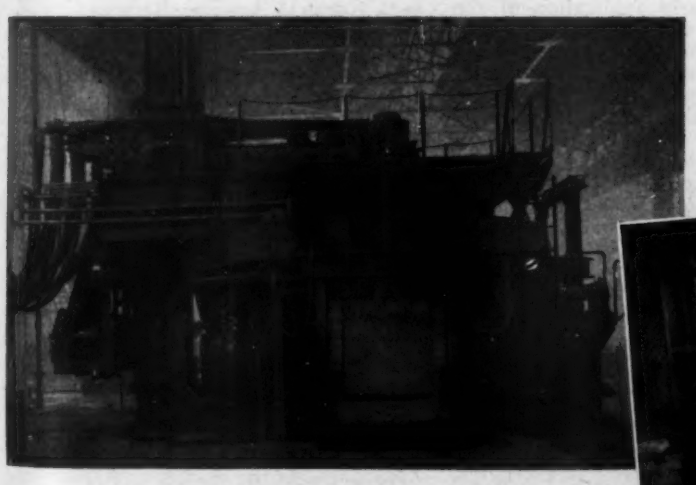
Stockpiling of fuels, both regular and synthetics, was discussed by oil industry leaders before Congressional committees last month.

P. C. Keith, president of Hydrocarbons Research, Inc., outlined these three steps which Congress might take to get the synthetics industry under way by private operation: 1) permit the military to buy and stockpile synthetic oil; 2) authorize the RFC to continue making self-liquidating loans for construction and operation of synthetic plants; and 3) revive wartime tax certificates of necessity which allowed a 20 percent yearly allowance for depreciation and obsolescence.

As to stockpiling of synthetics, Keith thought the synthetic industry could be created—with or without government loans, but no subsidies, to produce 750,000 barrels daily over the whole ten-year period. He said 750,000 barrels daily could be stored during the first five years and during the last five years the

2,000,000 Volt X-Ray Machine

Induction Furnaces from 600 to 2,000 pounds capacity



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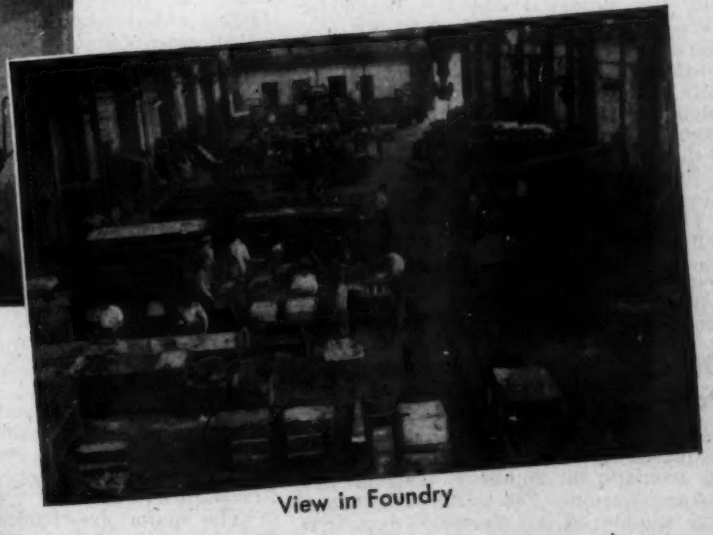

View in Foundry

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same production would continue which combined with the oil stored would give the military 1.5 million barrels daily. The remaining 500,000 barrels daily would come from rationing.

This plan would be sounder, he declared, than for the government to undertake development of a $9 billion industry with 2 million barrels daily capacity. Production facilities under his plan would cost $3 billion or 37.5 percent of the plant necessary for turning out 2 million barrels daily.

Keith declared that "if it were the wise thing to do, the oil industry can tomorrow, with sureness, built plants to transform coal into oil."

Eugene Ayres, a manufacturing research official for Gulf Oil Corporation, testified before the Short subcommittee that government subsidy will be required if a large synthetic liquid fuels production program is to be launched soon. Industry at this time "can't afford to take the gamble" to finance construction of commercial-size synthetic plants," he declared. Pilot plant work will be undertaken by the industry without subsidy if a general plan for synthetics production offers reasonable expectation of profit, he continued.

Ayres favored proposals for building three large commercial-size plants, as suggested by the Interior Department (see page 138). He would not say whether these plants should be built by government or industry.

Murphree's Plan

Dr. E. V. Murphree, president of Standard Oil Development Corporation, testified that if the military would give industry "reasonable notice" a stockpiling program—perhaps without development of commercial production of synthetic liquid fuels—can be worked out by private companies to provide the armed forces with 2 million barrels daily of products for a national emergency.

"A stockpiling program would in itself create oil product producing capacity over and above civilian needs," he said. "If potential military needs be taken as 2 million barrels daily for five years, and if it be assumed that civilian consumption is reduced 500,000 barrels daily through rationing, then it can be calculated that a program of stockpiling 500,000 barrels daily for five years would at the end of this period put the country in position for meeting emergency military needs."

The oil would be stored above ground under Murphree's suggested program which he said possibly could be met without construction of large commercial-size fuel plants.

Oil Emulsion Increases Paper Pulp Production

High grade paper pulp production can be increased 10 percent through use of an aromatic oil emulsion developed by Socony-Vacuum Oil Company, Inc., it was announced last month.

Socony-Vacuum's product, designated S/V Sovalent 911, contains approximately 70 percent of an effective petroleum solvent oil and is capable of standing high dilution with water or acids normally used in the sulphite pulping processes.

Cities Service and Kellogg Disclose Joint Plans for Synthetic Fuel Research

A merger of the synthetic fuel program of Cities Service Oil Company with that of The M. W. Kellogg Company, petroleum engineers, has been in effect since 1946 and Kellogg is now prepared to license synthetic fuel plants on behalf of both companies, it was announced last month.

"The combination of programs was a natural result of the complementary activities of both companies over a long period of time," a statement said. "Cities Service has long been interested in the production of chemicals from natural gas and Kellogg has approached the problem from the standpoint of synthesizing liquid fuel and by-product chemicals from natural gas. Test runs in the companies' pilot plants have demonstrated an improved control of quantity and quality of product and extension of length of runs to give appreciably great on-stream efficiency." As a result, the manufacture of synthetic fuel from natural gas is now considered commercially sound, the statement says.

Form Plans for Future

"The announcement is being made now because of the widespread publicity the subject has received recently and the companies' belief that facts on this research development should be made available so that government and industry may be fully informed and properly equipped to form plans for the future," it was said.

The statement highlighted four major points in the successful fulfillment of the work through many years: 1) Kellogg's pioneering and continuous development in this field since the middle 30's; and their early application of the fluid principle to the synthesis of liquid fuel; 2) Cities Service's experience covering more than 20 years with the chemistry of natural gas; 3) The successful incorporation of advancements made by both companies in their latest pilot plants at Lake Charles, La., Tallant, Okla., and Jersey City, N. J.; These advancements demonstrate the economic possibilities of the process to date; and 4) The continuation of joint research and development on a full scale pointing toward processing refinements that will even further improve the economics of the process.

Initial research by the Cities Service organization in the production of chemicals from natural gas by means of direct oxidation was begun as far back as 1926, it was explained while "the first research into the synthesis of liquid fuel by an American firm was initiated in the Kellogg Laboratories in the middle 30's. Subsequently Kellogg engineers made a thorough field survey in Germany, and by arrangements with the developers of the Fischer-Tropsch process in Germany they studied details of that process," carrying on where Fischer-Tropsch left off.

The major drawback to the original system of liquid fuel synthesis from the American point of view centered on the German system of reaction which was found unsuited to volume production along the American lines, and "one of the pioneer contributions by Kellogg in solving this problem was the adaptation of the fluid catalyst principle to liquid fuel synthesis," the statement continued.

The Cities Service organization has also had extensive experience with the actual commercial operation of plants employing the fluid technique through its operation of Kellogg-built fluid catalytic-cracking units.

At the end of the war, the synthesis programs were stepped up and development work was undertaken on a far greater scale. The oil company's program concentrated on recovering by-product chemicals produced by the process and its development, is said to have "substantially improved the economies of commercial plants." The joint research will continue seeking improvements in operations and will include the synthesis of fuels from other materials.

Dr. J. H. James Dies

Dr. Joseph Hidy James, 79, professor emeritus and first head of the Department of Chemistry and Chemical Engineering at the Carnegie Institute of Technology, died February 12 in his Pittsburgh home.

Dr. James, for more than 40 years an educator, author and leader in the fields of chemistry and chemical engineering, was born in Jeffersonville, Ohio, had conducted much research and held patents on acetylene storage and oxidation products, of petroleum.

George Monroe Dies

George Stuart Monroe, 55, for the past 24 years a research chemist with Universal Oil Products Company, died suddenly, February 25, at his home, 6526 Fairfield Avenue, Berwyn.

Monroe was graduated from the University of Illinois in 1917, with the B. S. degree in chemistry. He joined UOP in 1924 after serving with the Newport Company. Many patents dealing with the treatment of hydrocarbons have been issued to him.

August C. Klein Dies

Dr. August C. Klein, 60, vice president and engineering manager of Stone & Webster Engineering Corporation, died February 3 while on vacation in Montego Bay, Jamaica, B.W.I.

Klein had been continuously engaged in engineering work since 1908 except during World War I, shortly after which he became connected with Stone & Webster. In 1929 he became the company's chief mechanical engineer and in 1945 engineering manager. A year later he was elected vice president. He did notable work along atomic power lines during World War II, in recognition of which he was awarded a doctorate by Stevens Institute of Technology, his alma mater.

Roy B. Jones Dies

Roy B. Jones, 64, founder and president for 27 years of Panhandle Producing and Refining Company, died February 29 in Wichita Falls, Texas. He has been active in petroleum circles and during World War II was a PAW director. He also served as a director of American Petroleum Institute.

SCIENCE and TECHNOLOGY ABSTRACTS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

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DR. E. H. LESLIE and DR. H. B. COATS

Fundamental Physical and Chemical Data

Thermal Conductivity of Liquids. GERALD PALMER, *Ind. and Eng. Chem.* **40** (1948) pp. 89-92.

Little progress has been made in the last 20 years in correlating thermal conductivity of liquids with other data. The author reviews some of the efforts that have been made. Liquids divide into two classes—those that can be fitted with empirical equations and those for which the conductivity deviates considerably. In this latter class are the associated liquids such as water and the alcohols. The author discusses hydrogen bonding in associated liquids as an explanation of the anomalies in the thermal conductivity of glycols and alcohols. A plausible mechanism of heat conduction in these liquids is suggested, and on the basis of this theory, an improved equation was developed and tested for forty-eight liquids. The results are presented in tabular form. Bibliography includes 13 references.

The Thermodynamics of Butadiene-1,2 from Calorimetric and Spectroscopic Data. J. G. ASTON AND G. J. SZASZ, *Jour. Am. Chem. Soc.* **69** (1948) pp. 3108-14.

The heat capacities of butadiene-1,2 were measured from 14 to 284°K. The solid-liquid equilibrium temperature and the heat of fusion were determined. The melting point is 136.95°K. The vapor pressures were determined from 200 to 289 K. The results were represented by an equation leading to a value for the normal boiling point and to values of the heat of vaporization at 230, 250 and 290°K. The normal boiling point is 10.84°K. The heat of vaporization was determined at 273.25°K. An assignment of the fundamental frequencies was made, and the comparison between the calculated and observed entropies yielded a value of 1650 ± 400 cal./mole for the potential barrier hindering the internal rotation of the methyl group.

Vapor-Liquid Equilibria in Hydrocarbon Systems. STUART T. HADDEN, *Chem. Eng. Progress* **44** (1948) pp. 37-54.

A practical working procedure is given for obtaining vapor-liquid equilibria in hydrocarbon systems from low pressures up to the convergence pressure of the system. The principal correlations include three nomograms for ideal equilibrium-vaporization constants, K's from —200° F. to 1000° F. at pressures from 10 to 2000 psia. Range of materials considered includes hydrogen, light paraffins, and mono-olefins up to narrow boiling range cuts boiling at 1100° F. Correlations are presented for obtaining the deviation of the K's from their ideal values as the convergence pressure is approached. Correlations are given for obtaining K of nonhydrocarbons frequently occurring in hydrocarbon streams either as impurities or as process materials. The present paper is the first half of a full presentation of the subject. The literature is reviewed in great detail.

The C-H Bond Energy in Toluene and Xylenes. M. SZWARC, *Nature* **160** (1947) p. 403.

The pyrolysis of toluene and of the xylenes was found to be a homogeneous first-order gas reaction. The first step is the decomposition into benzyl or xylyl radicals and hydrogen atoms. Further reaction steps are outlined. The final reaction was the dimerization of the benzyl radicals. The energy of activation are for toluene 77.5 kcal., for m-xylene 75.5 kcal., for p-xylene 75.0 kcal., for o-xylene 74.0 kcal. The carbon-hydrogen bond strength of these compounds is from 24.5 to 28 kcal. smaller than it is for methane (102 kcal.) and the difference is larger than the theoretically calculated value of 16 kcal.

The Phase Behavior of Sodium Stearate in Anhydrous Organic Solvents. GEROULD H. SMITH AND JAMES W. MCBAIN, *J. Phys. & Colloid Chem.* **51** (1947) pp. 1189-1204.

Phase diagrams were determined for the systems sodium stearate-hydrocarbon at temperatures from 25 to 310 deg. C. for the following hydrocarbons: heptane, iso-octane, benzene, toluene, ethylbenzene, o-, m-, p-xylenes, cumene, cyclohexane, p-cymene, and butylbenzene. The soap was found soluble to the same extent at any given temperature in all of the hydrocarbons except the last two. This discrepancy was believed to be caused by impurities in these two hydrocarbons. In each case the soap and the solvent were carefully dried. All the phase diagrams were similar, and showed: 1) a 2-phase gel, 2) a golden or orange liquid-crystalization phase, 3) a white, waxlike liquid-crystalization phase, 4) an isotropic solution, and 5) an isotropic jelly, continuous in phase with the solution. All of the phase changes observed were reversible and followed the phase rule.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Dihydroxybiphenyl monosulfonic acids
Pyrogallol monomethyl ether monosulfonic acids
Sulfonated gallic acid
Sulfonated tannin
1-Hydroxy-3-butanone
2,6-Diisopropyl-p-cresol
Ethyl vanillate
1,1,1-Trifluoropropanone
2-Methyl-1,2,3-trihydroxybutane
2-Methyl-2,3,4-trihydroxybutane
2-Methyl-4-hydroxybutyraldehyde cyanohydrin
3-Methyl-4-hydroxybutyraldehyde cyanohydrin
Undecylaldehyde
4-Phenyl-2-aminobutyric acid
Dithenoylmethane
Montanic acid
4-Diethylamino-2-nitrosophenol
Acenaphthylene
d-sec. Butylcarbinol
Heneicosane
4-Hexane-2-one

Chemical Compositions and Reactions

Alkylbenzenes from Refining Processes. Alkylbenzenes in the C_9 Fraction from Five Different Catalytic Petroleum Refining Processes. A. J. STREIFF AND F. D. ROSSINI, *J. Research Natl. Bur. Standards* **39** (1947) pp. 303-8.

The Bureau of Standards, as part of API Research Project No. 6, was requested to determine the individual alkylbenzenes in the C_9 fraction of the product from five different catalytic petroleum refining processes, namely, hydroforming, two-pass fixed bed, three-pass fixed bed, low-temperature fluid, and high-temperature fluid. Results indicate that the relative amounts by volume of the four C_9 alkylbenzenes are not greatly different in the five products and were, on the average, as fol-

lows: ethyl-benzene, 12; o-xylene, 21; m-xylene, 48; and p-xylene, 19. The relative amounts of the four alkylbenzenes are approximately equal to those that would be expected at thermodynamic equilibrium at the temperature at which the material was produced.

The Isomerization Equilibriums of the Butanes, Pentanes, Hexanes, and Heptanes. J. J. B. VAN EIJK VAN VOORTHUIJSEN, *Rec. Trav. Chim.* **66** (1947) pp. 322-34.

The isomerization equilibrium for the butanes were determined by passing butane and HCl over $AlCl_3$ on "Norit CC" at 100, 150 and 200° C. For the higher alkanes the determination was made in an autoclave. The products were analyzed by a fractionation. Neopentane, neoheptane, 3,3-dimethyl-pentane, and 3-ethylpentane were not produced under these conditions, and neoheptane failed to isomerize. The results for the heptanes deviated considerably from the predictions of thermodynamics.

Polymerization of Pentenes. V. N. IPATIEFF AND R. E. SCHAAD, *Ind. and Eng. Chem.* **40** (1948) pp. 78-80.

3-Methyl-1-butene and a mixture of 2-methyl-1-butene and 2-methyl-2-butene were polymerized to decenes in the presence of solid phosphoric acid catalyst at 83° C. and at 100° C. Catalytic hydrogenation was used to convert the decenes into decane fractions with 94.6 octane number by the Motor method. During the polymerization of 3-methyl-1-butene at 83° and 100 C., 8 percent of the 3-methyl-1-butene charged was isomerized into higher boiling pentenes, mainly 2-methyl-2-butene. The data are presented in some detail in five tables and a bibliography of four references is included.

Manufacture: Processes and Plant

Heat Tranfer. GEORGE T. SKAPERDAS, *Ind. and Eng. Chem.* **40** (1938) pp. 39-41.

The paper is a review included in the Unit Operations Review. Among the subjects considered are convection film coefficients, condensation coefficients, boiling coefficients, conduction, exchanger design and operation, and a number of miscellaneous topics. A bibliography of 48 references is included.

Heat Transfer Symposium. *Chem. Eng.* **55**, No. 1 (1948) p. 134.

The article is an editorial summary of a symposium on heat transfer held at Oak Ridge, Tenn., under the sponsorship of the Nuclear Energy Powered Aircraft Division of the Fairchild Engine and Airplane Corporation. Twenty-eight speakers from industry and the universities presented papers on convection, conduction, radiation, boiling, condensation, mathematical methods, and materials of construction. The papers are briefly reviewed.

Heat Transfer. Local and Average Coefficients for Air Flowing Inside Tubes. ALBERT CHOLETTE, *Chem. Eng. Progress* **44** (1948) pp. 81-8.

The investigation covered a study of the heat transfer coefficient in the transition region between streamline and turbulent flow. Measurements were made of the local coefficients of heat transfer for flow inside tubes. Heat was transferred from steam to air. A steady-state method was used. The apparatus is described in some detail and the data are presented in tabular and graphical form. Recommended equations are given for determining heat transfer in the three regions: streamline, transition, and turbulent.

Condensation of Vapors on Outside of Finned Tubes. KENNETH O. BEATTY, JR. AND DONALD L. KATZ, *Chem. Eng. Progress* **44** (1948) pp. 55-70.

Data are given on condensing-film coefficients for propane, n-butane, n-pentane, methyl chloride, sulfur dioxide, and Freon 22 on the outside of a horizontal integral spiral-finned tube. The tube had 16 fins per inch with fins about 1/16 inch high. Film coefficients were determined from over-all heat-transfer data by a modification of the method proposed by Wilson. It was found possible to correltae all the condensing coefficients, within a maximum error of +7.2 percent and —10.2 percent, by the modified Nusselt equation. The equivalent diameter used in this equation was calculated by treating the finned tube as vertical surfaces corresponding to the fins, and to a horizontal tube surface. The paper includes an interpretation of the Wilson method for experimental data taken with a constant over-all temperature difference. The apparatus and procedure are described in considerable detail and the data are presented fully in tabular and graphical form.

Fluid Dynamics. DONALD F. BOUCHER, *Ind. Eng. Chem.* **40** (1948) pp. 32-8.

This review, included in the annual unit operations review, covers the field of fluid dynamics for a two-year period extending roughly from October 1945 through September 1947. Among the subjects covered are fluidized solids, gas turbines and jet propulsion, flow at ultrahigh vacuum, fundamental and theory of fluid dynamics, pressure drop in channels (single-phase flow), two-phase flow in channels, flow of solids, drag and flow around objects, flow through equipment, pumping machinery, jets, cavitation, metering, vortex refrigerating device, anomalous viscosity and a number of miscellaneous topics. A bibliography of 267 references is included.

Dimensionless Groups in Fluid Friction, Heat, and Material Transfer. A. KLINKENBERG AND H. H. MOODY, *Chem. Eng. Progress* **44** (1948) pp. 17-36.

The paper is a review of widely scattered literature in this field, although the emphasis, admittedly, is placed on European work. A diagram is presented showing the formal similarities of differential equations for conservation of momentum, of heat, and of matter and which gives a survey of dimensionless groups to be considered in problems of fluid friction, heat transfer, and mass transfer. Examples are given illustrating the use of these groups and the services the chart can render in the field of chemical engineering. There is a tendency for an ever increasing use of the theory of similitude so as to have our knowledge cast into the form of relations between dimensionless groups of variables. A coordinated treatise on these groups is given in such a way as to facilitate a survey of the whole field and to be of help for quick refernce. Comments on the fundamentals of the meaning and use of dimensionless groups is made. A bibliography of 103 references is included.

High Temperature Distillation. T. J. WALSH, *Ind. Eng. Chem.* **40** (1948) pp. 13-16.

This is one of a series of reviews of chemical engineering unit operations and is the third annual review of this type. Among the subjects covered are the principles of distillation, distillation calculations, fractionating columns, extractive and azeotropic distillation, and distillation data. A bibliography of 61 references is included.

Solvent Extraction. JOSEPH ELGIN, *Ind. and Eng. Chem.* **40** (1948) pp. 53-6.

The paper is one included in the Unit Operations Review. Among the subjects considered are phase equilibrium, solubility, and solvents, mass transfer and equipment, design and process data and applications of solvent extraction. A bibliography of 86 references is included.

Method for Designing Packed Columns. M. J. SIMON AND M. A. GOVINDA RAU, *Ind. and Eng. Chem.* **40** (1948) pp. 93-6.

At present time packed columns are designed using over-all transfer coefficients and over-all HTU values. This method is defective, for it assumes a constant value for the over-all transfer coefficients, whereas it is well known that the over-all coefficients are a function of the slope of the equilibrium curve and are therefore variable functions. By assuming that the slope of the equilibrium curve is practically constant over a short length of the curve in an equilibrium unit, the authors have been able to derive a general equation for designing all types of packed columns in which the method of material transfer from one phase to the other is by diffusion across interfacial films. The equation can be used either for evaluating the height of a packed column or conversely for determining the individual transfer coefficients. A typical example is considered for the use of a continuous still for enriching ethyl alcohol-water, packed with 1 inch Raschig rings and operated at a vapor rate of 15.0 pound moles per hour and a reflux ratio of 2.

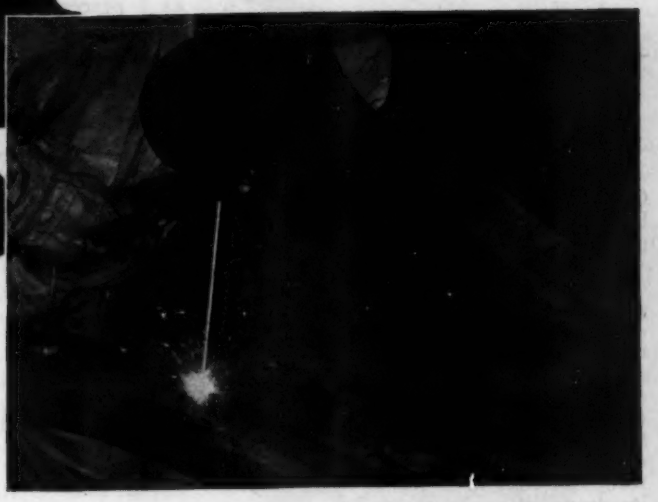
Distribution in Hydrocarbon-Solvent Systems. T. F. BROWN, *Ind. and Eng. Chem.* **40** (1948) pp. 103-6.

The properties of double nonconsolute ternary hydrocarbon solvent systems are discussed and compared with the more usual single nonconsolute pair type. A new relation for the extrapolation of tie-line data for such systems has been established using the equations derived by Varteressian and Fenske. An interesting correlation of Bachman plots has been made and extended to two newly determined quarternary systems, the saturation and equilibrium data for which are given. Suggestions are made for the application of these methods to petroleum systems of narrow boiling range in contact with a solvent. A bibliography includes 11 references.

The Alkylation of Isoparaffins with Olefins in the Presence of Sulphuric Acid. Part. 1. The Composition of an

Southwest Headquarters

. . . for pipe welding equipment and "know how"



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Aviation Alkylate. FRANK MORTON AND ALAN R. RICHARDS, *Jour. Inst. of Petroleum* **33** (1948) pp. 697-720.

Analyses of alkylates given in the literature are confined to the principal components, that is, isopentane and the three trimethylpentanes, and no accurate information has yet been given of the amounts and structure of the hexanes, heptanes, octanes, and nonanes that normally accompany the principal components. The work reported was undertaken to provide information concerning the nature and amounts of the various minor components. Aviation alkylate was submitted to repeated precise fractionation and the physical constants of the fractions determined. Infrared spectroscopic analysis of a number of the fractions was used to determine the composition of the alkylate. Details of the porous conditions of the feed stock analysis which give rise to the alkylate studies are given. Seventy-five fractions were separated, five of which were pure 2:2:4-trimethylpentane. The properties of all of the fractions are given in tabular form. Compositions of the entire alkylates is presented in tabular form and hydrocarbons not found in it are noted. The presence of 2:4-dimethylhexane in quantity equal to the amount of isopentane suggests that the former hydrocarbon should be included among the principal components.

Short-Cut Estimation of Welded Process Vessels. HARLAN HOW, *Chem. Eng.* **55** No. 1 (1948) pp. 122-6.

When time is more important than great accuracy the charts given in this article will give safe estimates of the cost of fabricating unfired pressure vessels in carbon steel, chrome nickel steel, stainless and nickel clad steel and the copper-silicon alloys such as Everdur and Herculoy. One chart presents cutting time and machine rate burden for flame cutting with automatic machines. A second gives the time for rolling plates 60 to 72 inches wide in various lengths and thickness. A third gives fitting and assembly, and total fabrication time for steel tanks and weldments. A fourth chart gives welding and edge preparation time and welding rod weight for U-69 butt welds in A-70 carbon steel. Welding time charts are also given for alloy steels and copper alloys. Further charts give machining time for flanged and dished heads, and steel plate flanges. The total cost will be the sum of material cost, labor and overall shop burden. The burden is usually from 90 to 120 percent of the total direct labor. To the direct cost must be added a burden to cover sales, administrative and engineering expense, which generally ranges from 7½ to 20 percent of the total cost. The final factor is this cost plus the manufacturing profit. It may be as low as 5 percent or as high as 20 percent of the sales price.

Products: Properties, Utilization and Analysis

Technique for Measuring Reactivity of Gasoline Antioxidants with Air. BARNEY R. STRICKLAND, *Analytical Chem.* **20** (1948) pp. 55-6.

Two of the more common types of organic compounds used as gasoline antioxidants-aminophenols and phenylenediamines are reactive with air. The rate and extent of their reaction with air at room temperature and atmospheric air pressure was measured. The paper is devoted largely to a discussion of the technique involved in making these measurements, for it is believed that the technique may be useful in other studies involving the absorption of gases in liquids. When the apparatus is started, the operation is entirely automatic. Typical results showing the reactivity of the antioxidants with air are presented.

Aluminum Stearate Gels for Use as Flame-Thrower Fuels. C. M. CARLEY, J. H. G. CARLILE, J. G. KING AND F. E. T. KINGMAN, *Jour. Inst. of Petroleum* **33** (1948) pp. 721-55.

The work of the Fuel Research Station concerning the invention and development up to full-scale manufacture of flame-thrower fuels consisting of aluminum stearate gels in petrol peptised with cresylic acid or mixed xylenols is given. Control of the manufacture of aluminum stearate is described, and the results of studies of the effects of peptisers and of various grades of petrol are recorded. Methods of manufacture were developed at the Fuel Research Station to a stage at which a mobile mixing plant of 750 gallons capacity was designed, built, and operated. Among the physical and chemical properties considered are: anomalous viscosity, variation of viscosity with temperature, and stability of gels on storage at various temperatures. Although the service fuel was satisfactory, attempts were made to effect improvements, mainly by the use of peptising agents other than the xylenols. It was found that the lower aliphatic alcohols decreased the temperature sensitivity of the fuels, Ethyl cellosolve as a peptising agent effected considerable economy in the amount of aluminum stearate required and increased the high temperature stability. Certain desirable properties of the gels, however, were conferred on them only by xylenols, and it is believed that mixtures of the peptising agents, chosen according to the properties required in the fuel, would afford the best solution to the problem of producing improved flame-thrower fuels.

Determination of Gaseous Hydrocarbons. ROBERT E. MURDOCK, FRANCIS R. BROOKS AND VICTOR ZAHN, *Analytical Chem.* **20** (1948) pp. 65-7.

A method is described for the rapid and quantitative determination of gaseous paraffins by combustion at 700° C. over precipitated copper oxide containing 1 percent iron oxide. This combustion agent has proved to be much superior to commercial copper oxide for the combustion of paraffin. The combustion of hydrogen is complete at 220° C. and the combustion of methane at 600° C. Preparation of the copper oxide catalytic material is described. The authors are of the opinion that the method has a great advantage over commonly applied methods that use copper oxide wire requiring a temperature of around 900° C., or combustion over a heated filament or catalyst that requires the addition of oxygen. Formation of explosive mixtures and the hazard created thereby are eliminated. Results of the method are of equal or superior accuracy and precision to those obtained by other combustion methods tested.

Determination of Cyclopropane by Selective Absorption. FRANCIS R. BROOKS, ROBERT E. MURDOCK AND VICTOR ZAHN, *Analytical Chem.* **20** (1948) pp. 62-3.

Cyclopropane can be determined in gases containing both olefins and paraffins by absorption of the olefins in acid mercuric sulfate reagent followed by absorption of the cyclopropane in 87 percent sulfuric acid. Ethylene can be distinguished from other olefins by a second analysis in which the order of absorbents is reversed, and cyclopropane plus olefins other than ethylene is absorbed in 87 percent sulfuric acid and then ethylene absorbed in acid mercuric sulfate reagent. The apparatus and procedure are described in some detail and typical analyses of hydrocarbon mixtures are presented.

Mass Spectrometer Analysis of Some Liquid Hydrocarbon Mixtures. R. A. BROWN, R. C. TAYLOR, F. W. MELPOLDER AND W. S. YOUNG, *Analytical Chem.* **20** (1948) pp. 5-9.

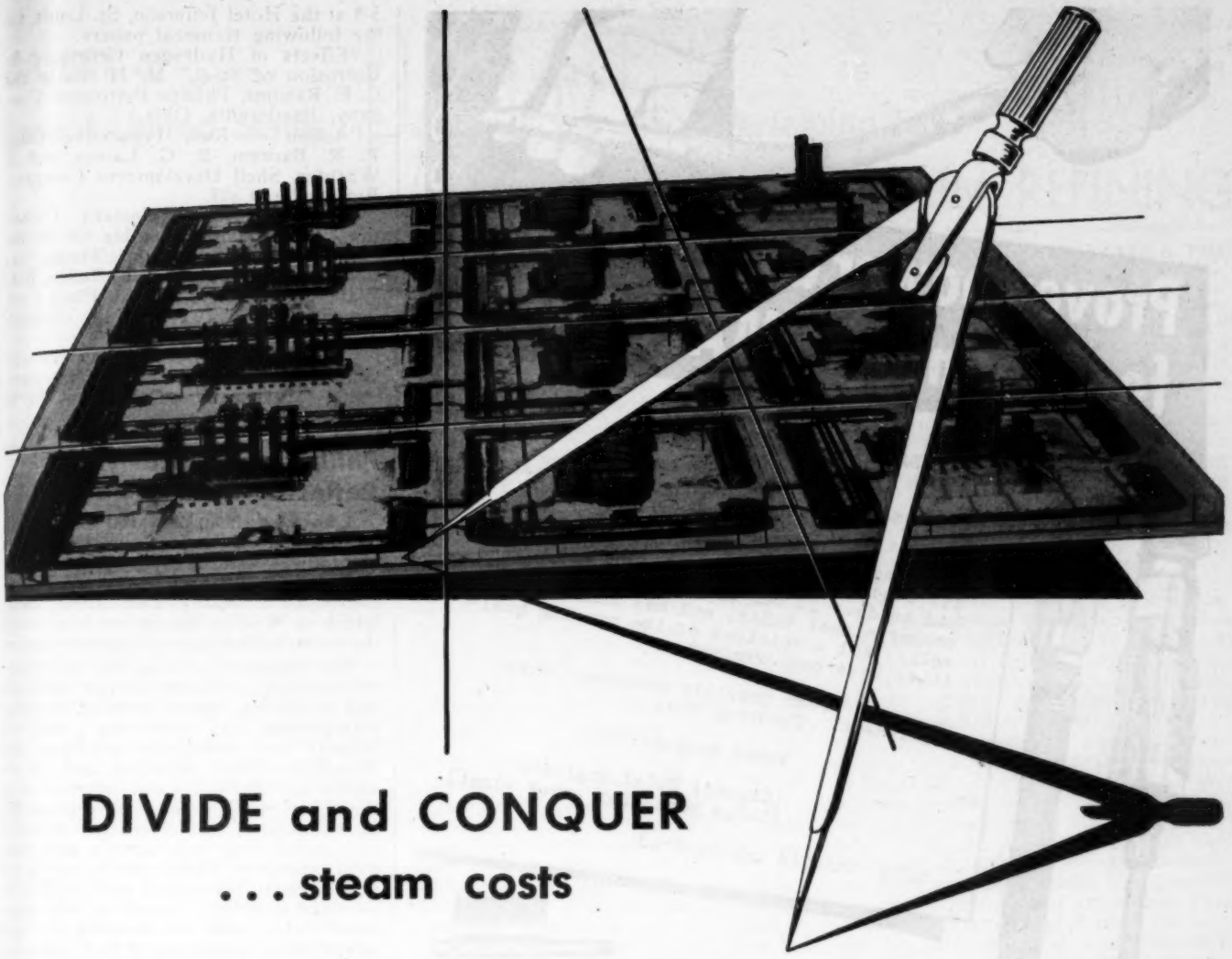
Applications of mass spectrometer analysis of normally liquid mixtures in the C_6 to C_8 range has been handicapped by insufficient data. The authors give spectrometer analyses of a number of known synthetic mixtures in this range for the purpose of establishing accuracy, and to illustrate by several examples the application of the method to actual mixtures. The hydrocarbons that it is necessary to consider are paraffins, cycloparaffins, mono- and diolefins, and aromatics. The separation and characterization of the olefins is discussed briefly. The application of the spectrometer to these compounds waits considerable experimental study. Accuracies attainable for the other individual compounds in a number of different mixtures are given and typical analyses of several hydrocarbon fractions in the gasoline boiling range are presented. It is concluded that a substantial number of the paraffins, cycloparaffins, and aromatics occurring in this boiling range can be individually determined.

Infrared Analytical Techniques for Analyzing C_5 Mixtures. VERNON THORNTON AND ANNETTE E. HERALD, *Analytical Chem.* **20** (1948) pp. 9-10.

Mixtures of C_5 hydrocarbons were analyzed in the vapor phase rapidly and with sufficient precision for plant control. The analytical techniques were greatly simplified by the discovery that the extinction per unit pressure was constant over a pressure range of 50 to 650 mm. of mercury at 30° C. for the two C_5 paraffins and six C_5 olefins that were studied. Small variations in concentrations of components appearing in fractionation products were quickly measured by the infrared method, even though the components possessed relatively weak absorption bands. This was accomplished by comparing with a reference mixture. The application of the method to the control of the fractionating column is breifly described.

Papers for NACE Meet

Included on the program for the 1948 conference of the National Association of Corrosion Engineers, scheduled April



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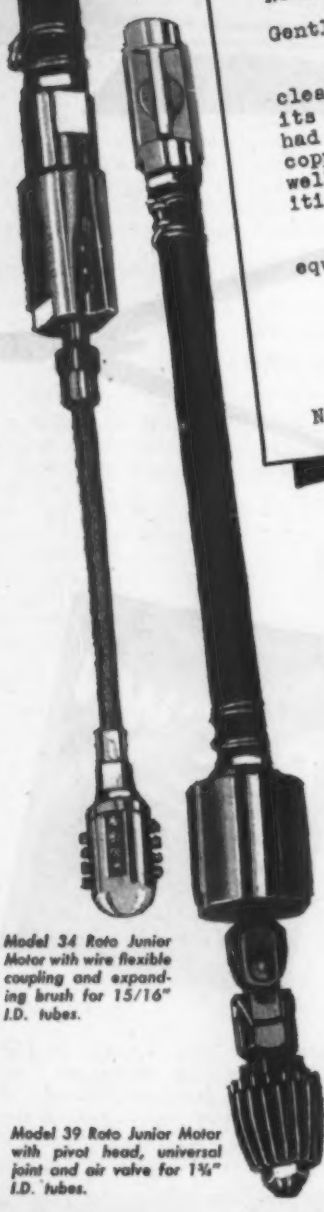

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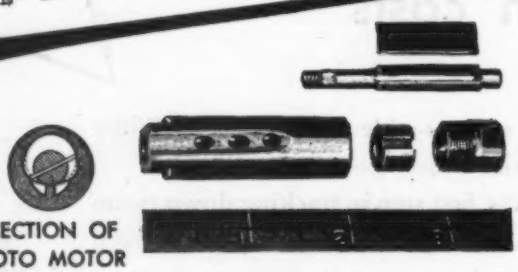

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5-8 at the Hotel Jefferson, St. Louis, are the following technical papers:

"Effects of Hydrogen Generated by Corrosion of Steel," M. H. Bartz and C. E. Rawlins, Phillips Petroleum Company, Bartlesville, Okla.

"Action of Rust Preventive Oils," E. R. Barnum, R. G. Larsen and A. Wachter, Shell Development Company, Emeryville, Calif.

"Sour Crudes—Equipment Protection," E. R. Camp, Humble Oil & Refining Company, Baytown, Texas.

"Corrosion Problems in Boiler Feed Waters and Waters Used in Plant Cooling Systems," S. T. Powell, chemical engineer, Baltimore.

"Brine Corrosion in the Oil Industry," Gulf Research Development Company.

The All-Corrosion Exhibition will be held concurrently in the hotel.

Phillips' Technical Work Reflected in New Book

A book has been prepared for the purpose of acquainting customers, licensees and others with a brief review of the technical and patent assets of Phillips Petroleum Company, Bartlesville, Okla., which in 30 years has grown into one of the nation's leading petroleum companies.

The organization is a fully integrated oil company, exploring for raw materials and producing, manufacturing, refining, transporting and marketing crude oil, natural gas, petroleum products and chemicals. Their technical and patent assets are derived from operations in these various fields and are represented by voluminous and diversified technical and engineering data, patents, and practical experience. Petroleum research and development, because of such highly diversified interests, include widely separated fields such as electronics, light, geophysics, emulsions, P-V-T relations of hydrocarbons, distillations at temperatures as low as —350° F., refinery processes, hydrocarbon reactions of all sorts, organic chemical synthesis, catalysts, et cetera.

No single operating department of any company could efficiently pursue such a wide variety of problems; so for this reason Phillips has set up a centralized research and development organization which is responsible directly to the company's executive management. The extent of Phillips' activities in research and development work is indicated by its ownership of more than 1000 active patents. It also has approximately 150 licensees using its processes and equipment.

The object of this book is primarily to reflect the progress of the company from a technical point of view.

Pennington Joins Slick Research Organizations

Dr. J. V. Pennington, consulting engineer, petroleum geologist and publicist, has been appointed director of the Houston units of the Foundation of Applied Research and of Southwest Research Institute. He is a former vice president of Reed Roller Bit company and at one time was a member of the faculty of Rice Institute.

The Institute and Foundation, both non-profit scientific research organizations established by Tom Slick, San Antonio oilman and rancher, have home offices in San Antonio but are planning a large laboratory in Houston.

DIGEST of Recent United States PATENTS Pertaining to PETROLEUM REFINING

AND COVERING PATENTS PUBLISHED IN THE OFFICIAL GAZETTE DATED DECEMBER 16, 23 AND 30, 1947, AND JANUARY 6, 1948

Compiled by HEINZ HEINEMANN

REFINING

U.S.P. 2,432,771. Hydrocarbon Separation by Azeotropic Distillation with Trioxane. G. R. Lake to Union Oil Company of California.

A complex hydrocarbon fraction containing various chemically similar components, e.g. aromatic and non-aromatic hydrocarbons, which ordinarily distill in the same temperature range, is azeotropically distilled in the presence of a sufficient amount of trioxane to vaporize at least one of said different components, e.g. the non-aromatics, together with the trioxane. At least one of the other components, e.g. the aromatics, is left in the residue substantially completely separated from the other components.

U.S.P. 2,432,839. Corrosion Inhibitors-Nitrite Salts of Primary Amines. A. Wachter and N. Stillman to Shell Development Company.

The patent relates to a non-corrosive composition which comprises a major proportion of an organic material with a pH of at least 7, particularly a light hydrocarbon oil, coming in contact with water when in use, and a dissolved minor proportion of a nitrite salt of a primary amine, such as mono-cyclohexylamine nitrite, beta-phenylethylamine nitrite, or 3,3,5-trimethylcyclohexylamine nitrite. The nitrite used shall be stable at ordinary temperature, soluble in water and in the organic material used and normally non-reactive with the latter. It inhibits corrosion of metal surfaces by water.

U.S.P. 2,432,840. Corrosion Inhibitors-Nitrite Salts of Tertiary Amines. A Wachter and N. Stillman to Shell Development Company.

This patent resembles patent 2,432,839. In the present case the nitrite salt of a tertiary amine, such as trimethylamine nitrite, tricyclohexylamine nitrite, or N-n-butyl morpholine nitrite, is employed as the corrosion inhibiting additive.

U.S.P. 2,433,030. Separation of Olefins from a Hydrocarbon Stream. J. H. Cone to Standard Oil Development Company.

A predominantly C_4 hydrocarbon feed stock comprising olefins is contacted with H_2SO_4 to form an extract. This extract is washed with a napthene hydrocarbon oil (preferably 1-20 volume percent) to remove foaming agents. The washed extract is heated while reducing the pressure to cause the vaporization of a major portion of the hydrocarbons, i.e. the olefins, from the extract. The naphthene hydrocarbon oil employed shall be substantially free from naphthenic acids.

U.S.P. 2,433,033. Stabilization of Motor Fuels. P. L. DeVerter to Standard Oil Development Company.

The motor fuel according to this patent comprises a major proportion of a gasoline base stock, 0.5-6 cc. of tetraethyl lead per gallon of gasoline, and 0.1-1.0 lb. of $ZnCl_2$ per 1000 gallons of fuel. A small amount of a low boiling alcohol, ether, or ketone can be added as a solubilizer for the $ZnCl_2$. The $ZnCl_2$ additive inhibits deterioration of the leaded gasoline by oxidation during storage.

U.S.P. 2,433,243. Diesel Fuel Oils. H. G. Smith, T. L. Cantrell and J. G. Peters to Gulf Oil Corporation.

The diesel fuel oil according to this patent contains a small proportion (e.g. 0.004-0.04 percent by weight) of an aliphatic amine soap made from a long chain primary aliphatic amine with at least 10 C atoms and a correspondingly long chain aliphatic monocarboxylic acid, and also contains a correspondingly small proportion of a polyvalent metal salt of an N-alkenyl phthalamidic acid. Corrosion, wear, gum formation and ring sticking are retarded in the use of this fuel. Examples of the two types of additives employed are cocoamine oleate and the calcium salt of N-9,10-octadecenyl phthalamidic acid.

U.S.P. 2,433,364. Hydrocarbon Reporming Process and Products thereof. J. E. Harvey, Jr., R. H. White, Jr. and J. A. Vaughan to J. E. Harvey, Jr. and Southern Wood Preserving Company.

The process of this patent is similar to that of patent 2,433,363. The wood preserving impregnant is composed of a hydrogenated petroleum oil with a content of about 15-20 percent of residual materials preponderantly boiling between 210-355° C. and containing not less than 70 percent aromatic of defined sp.gr.

U.S.P. 2,433,365. Production of Valuable Hydrocarbons. J. E. Harvey, Jr., R. H. White, Jr., and J. A. Vaughan to J. E. Harvey, Jr. and Southern Wood Preserving Company.

The process of this patent is similar to that described in patents 2,433,363-4.

U.S.P. 2,433,465. Process for Effecting the Separation of a Monoolefin from a Diolefin. L. N. Leum, S. J. Macuga, and S. I. Kreps to The Atlantic Refining Company.

A mixture containing a mono-olefin and a diolefin of similar vapor pressure, e.g. a mixture of a butylene and butadiene, is subjected to a non-selective polymerization treatment. The resulting polymers are contacted with a depolymerization catalyst, such as fuller's earth, at a temperature sufficient to reproduce the mono-olefin in monomeric form while leaving the other polymers unchanged. A temperature of 400-1200° F. can, for example, be employed in the depolymerization reaction.

U.S.P. 2,433,286. Extractive Distillation of Hydrocarbon Mixtures. Using Hydrocarbon Solvents. A. C. McKinnis to Union Oil Company of California.

A mixture of normally gaseous hydrocarbons comprising paraffins, monoolefins and diolefins is extractively distilled in the presence of a solvent comprising a paraffin hydrocarbon boiling at least 25° F. above the b.p. of the mixture, to reduce the vapor pressure of the paraffin in the mixture to a greater extent than the vapor pressure of the mono- and di-olefins. Mono- and di-olefin are thus vaporized while the paraffin and the solvent remain as residue. The paraffin is then separated from the solvent by distillation. The monoolefin and the diolefin are separated from one another by distillation in the presence of a second solvent, viz. an unsaturated or aromatic hydrocarbon boiling at least 25° F. above the maximum b.p. of this olefin mixture. While the monoolefin is vaporized, the diolefin remains with this solvent in the residue and is then separated therefrom by further distillation. Pentane or hexane can be employed as the first solvent and benzene as the second.

U.S.P. 2,433,364. Hydrocarbon Reform-Hydrocarbons. J. E. Harvey, Jr., R. H. White, Jr., and J. A. Vaughn to J. E. Harvey, Jr. and Southern Wood Preserving Company.

The patent describes and claims a process for inducing toxicity to wood destroying fungi in a mixture of petroleum fractions boiling preponderantly above 270° C.

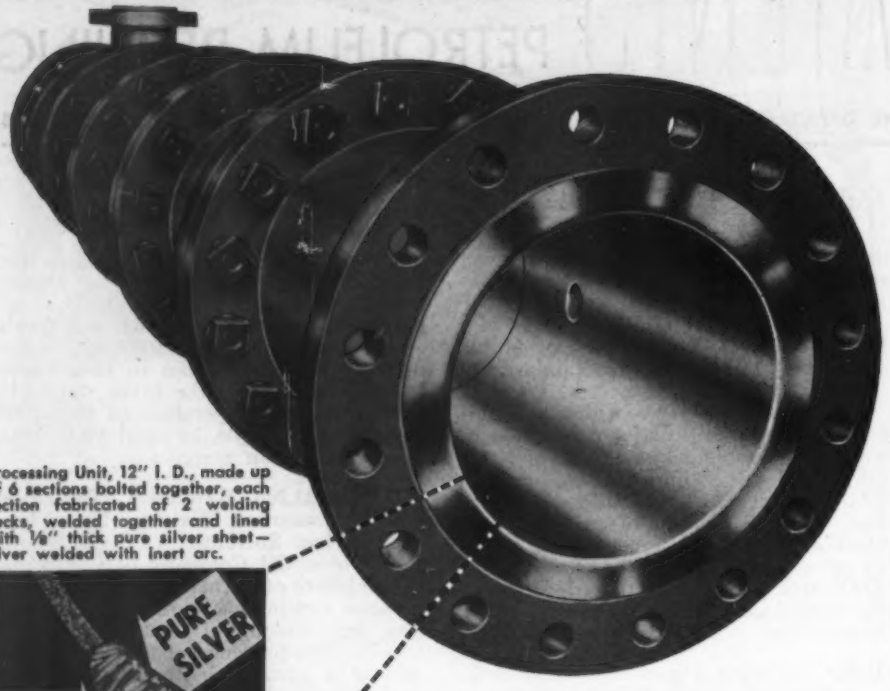
U.S.P. 2,433,716. Diesel Fuel Oils, H. G. Smith and M. L. Hill to Gulf Oil Corporation.

This patent is similar to patent 2,433,-243. In the present case the second additive is a salt of a divalent or trivalent metal and an N-alkenyl, N-alkylol phthalamidic acid. The calcium salt of N-9, 10-octadecenyl, N-2-hydroxy-propyl phthalamidic acid can, for example, be used for this purpose.

U.S.P. 2,433,751. Separation of Organic Compounds. B. S. Friedman to Universal Oil Products Company.

A mixture of hydrocarbons of differing degrees of saturation is extracted with a substituted aliphatic nitrile in

PURITY and PRECISION IN FABRICATION...



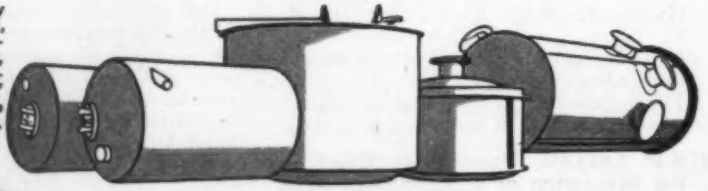
Processing Unit, 12" I. D., made up of 6 sections bolted together, each section fabricated of 2 welding necks, welded together and lined with 1/8" thick pure silver sheet—silver welded with inert arc.

Cross-section of Nooter-Weld before Grinding and Burnishing.

SILVER CLAD by the NOOTER-WELD PROCESS.....

Here's a good example of how the Nooter-Weld combines the properties of two entirely different metals — *heavy duty middle gauge steel* for pressure resistance and structural strength—with a pure silver for corrosion-resistance. The Nooter-Welds of the silver inert arc type (invisible because they are ground and buffed) are used for bonds and seam-welds. The steel is built up to pure silver without any dilution from the vessel wall to which it is bonded. This is essential to corrosion-resistance and to the successful performance of the unit. Nooter craftsmanship can always be identified by distinctive construction features—such as smooth, straight seam-welds—placement of fillets, etc., as well as precise fit-up.

Processing Equipment by Nooter—Converter Shell, 6'6" diam. 19'5" long—Hot Gas Filter Shell, 7'6" diam. 5'8" long—Sulphur Burner Shell, 8' diam. 17' long—Pump Tank, 9' diam. 6' long.



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which the nitrile and substituent groups are attached to different C atoms and in which the aliphatic portion contains 2-5 C atoms. An extract phase and a raffinate phase are formed, the extract phase containing the olefins and aromatics while the raffinate phase contains the saturated hydrocarbons, i.e. paraffins and naphthenes. Examples of the selective solvent to be used are: succinonitrile and beta-hydroxypropionitrile. The substituted aliphatic nitriles preferably used in this process should contain a strongly hydrophilic substituent group.

U.S.P. 2,434,239. Method of Producing Oil. J. A. Zublin.

A method for separating oil from sand, colloidal matter, and the like while the oil is being produced from a vertical well.

U.S.P. Re. 22,957. Residual Hydrocarbon Treatment. J. R. Bates to Houdry Process Corporation.

The patent relates to a cyclic process for treating liquid or liquefiable heavy hydrocarbons to remove tarry and coky material therefrom and produce a clean distillate stock. The heated charge containing vaporized and unvaporized material is fed during the endothermic period of reaction to a refractory separating zone after the latter had been used for an exothermic reaction to remove coky deposits therefrom, whereby the temperature of this zone had been raised above 1100° F. Rapid decomposition of the liquid material introduced into this zone during the endothermic period is caused, a vaporized material boiling above the gasoline boiling range and coke being formed. The feed rate of the charge to the separating zone is controlled to effect removal of the vaporized material within about 15 seconds or less in order to prevent any cracking to gasoline.

CATALYST PREPARATION, ACTIVATION AND REGENERATION

U.S.P. 2,432,503. Heater. E. V. Bergstrom and E. Utterback to Socony-Vacuum Oil Company, Inc.

The patent describes and claims an apparatus for rapidly heating granular solids, particularly such employed in high temperature reactions, e.g. in the thermal cracking of hydrocarbon oils by contacting them with highly heated refractory solid granules.

U.S.P. 2,432,543. Catalytic Converter. T B. Prickett and R. C. Lassiat to Houdry Process Corporation.

This patent relates to the special construction of an apparatus for carrying out chemical reactions in the presence of catalysts and particularly for transforming hydrocarbons. The apparatus permits indirect heat exchange between the catalyst and a heat exchange fluid both during the reaction and the regeneration periods of the catalyst.

U.S.P. 2,432,634. Cracking Hydrocarbon Oil with Silica-Magnesia Catalyst. C. L. Thomas to Universal Oil Products Company.

The catalyst used in the conversion of hydrocarbon oils according to this patent consists essentially of a dried and calcined mixture of a major pro-

This new seating arrangement

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Newly-designed Jenkins gate valve uses hard, corrosion-resistant wrought Monel seat rings to assure tightness . . . at oil pressure up to 400 psi.

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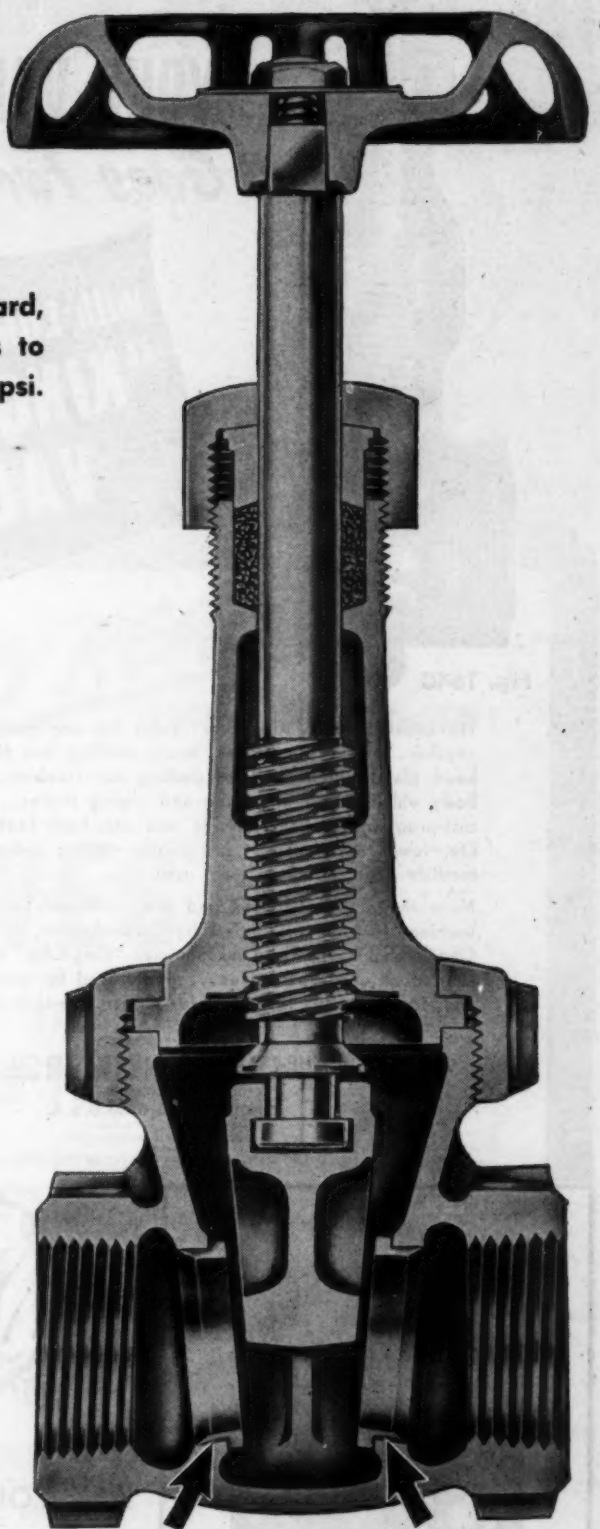

Cross section of new Jenkins valve. Arrows indicate wrought Monel seat rings expanded into valve body which resist wear and corrosion. Tight-fitting bronze wedge is easily replaced, enabling valve to last indefinitely. Available in ¼" to 2" sizes to handle 200 psi steam or 400 psi water, oil, or gas.

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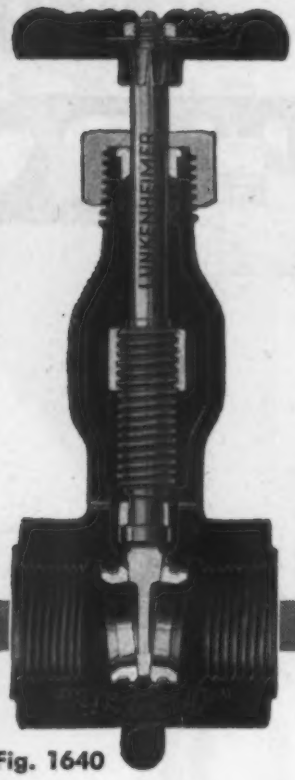

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Fig. 1640

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Note the ample, unobstructed drain channels and bronze thread bushing, features originated by Lunkenheimer, as was the "King-Clip" Valve itself. The Lunkenheimer "King-Clip" Valve is truly the king of all clip type valves... widely used for more than 50 years and, today, better than ever for longer, low-cost service.

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Manifold employing multiple Lunkenheimer "King-Clip" Gate Valves. Note the compactness of the installation and the convenience of the bolted bonnets, each of which is readily accessible. "King-Clip" Gate Valves are furnished in 21 standard types, with iron body-bronze trim, all-iron or iron body-alloy trims and with inside or outside rising stems for various service needs.

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portion (e.g. more than 65 percent) of silica hydrogel and a minor proportion of magnesia hydrogel.

U.S.P. 2,432,746. Process for Catalytic Cracking of Petroleum Hydrocarbons. W. W. Gary and R. B. Secor to Filtrol Corporation.

The activated clay catalyst used for catalytic cracking of petroleum hydrocarbons, e.g. a sub-bentonite, is produced by treating an acid activatable clay which has base exchangeable ions with a mineral acid to reduce substantially the alumina content of the clay and increase its activity. The acid is separated and the remaining clay, which contains residual titrable acidity, is reacted with ammonium hydroxide in an amount sufficient to introduce ammonium ions into base exchange position on the clay and to reduce the titrable acidity.

U.S.P. 2,432,934. Method and Apparatus for Catalytic Reactions. J. P. Rasor to Filtrol Corporation.

A stream of solid catalyst particles of high dielectric constant is passed between spaced electrodes through a high frequency electric field of high potential maintained between the electrodes. Reactant vapors are passed through this field in contact with the catalyst. This process makes possible an exact control of the heat requirements of the catalytic operation generated by the high frequency current within the body of the catalyst and to some degree also within the vapor.

U.S.P. 2,433,779. Preparation of Sols and U.S.P. 2,433,780. Preparation of Hydrocarbon Sols. M. D. Marshall to Monsanto Chemical Company.

Both these patents relate to the preparation of a stable and substantially anhydrous organosol composed of a collodial inorganic oxide, such as silica, and a high boiling hydrocarbon, such as toluene, by a particular process starting with the formation of an aquasol of the collodial inorganic oxide.

U.S.P. 2,433,869. Preparation of Contact Masses. H. A. Shabaker to Houdry Process Corporation.

The patent describes a method of producing a catalyst in the form of hard, low-density pellets highly stable to deactivation by steam by aging a hydrogel of silica containing alkali metal salts as an impurity immediately after its preparation and at a temperature of at least 70° F., and for at least 5 minutes in a certain relationship of temperature and period of treatment. The aged hydrogel is rapidly dried, then pulverized and washed to remove the impurities, filtered, again dried, formed into paste and cast into pellets which are then calcined.

U.S.P. 2,433,996. Hydrogen Chloride Recovery in a Butane Isomerization Process. J. W. Latchum, Jr., to Phillips Petroleum Company.

Normal butane is isomerized in the presence of HCl and $AlCl_3$. The patent describes the particulars of a process for treating the vaporous reaction effluent containing $AlCl_3$ with a non-volatile strong mineral acid to set free HCl from the $AlCl_3$ and to recover the HCl.

U.S.P. 2,434,040. Hydrogen Fluoride Recovery. B. F. Hartman to Socony-Vacuum Oil Company, Inc.

The patent relates to a process for

the alkylation of isoparaffins with olefins in the presence of liquid HF and describes a procedure for the recovery of HF from the light gases of the reaction effluent by treating them with fluosulfonic acid.

CRACKING AND REFORMING

U.S.P. 2,432,537. Production of Motor Fuels. R. H. Newton to Houdry Process Corporation.

For making motor fuels of improved quality and lead susceptibility, a charge of higher boiling hydrocarbons is cracked in the presence of a catalyst. A fraction rich in isopentane and a fraction rich in pentenes is separated from the cracked product. The pentene rich fraction is recirculated through the cracking zone along with the fresh charge in order to reduce the amount of C_5 unsaturates in the final motor fuel product. If desired, the dependantized gasoline and naphtha obtained from the effluent of the first cracking can also be re-cracked separately in a second cracking zone.

U.S.P. 2,432,644. Catalytic Conversion of Hydrocarbons. J. G. Alther to Universal Oil Products Company.

Hydrocarbon vapors are passed upwardly through a relatively dense bed of subdivided solid cracking catalyst under cracking conditions. Partially spent catalyst is suspended in a liquid hydrocarbon charge oil and then passed through a vaporizing zone, where a substantial portion of the oil is vaporized in presence of the catalyst. Heavy nonvaporous components of the oil are deposited on this catalyst. The thus contaminated catalyst is separated from the feed stock vapors, suspended in a stream of oxygen-containing gas and introduced into the lower portion of a bed of contaminated catalyst maintained under combustion conditions to regenerate all of the catalyst particles.

U.S.P. 2,432,744. Catalytic Cracking Process with Suspended Catalyst. W. W. Gary to Filtrol Corporation.

The powdered catalyst employed for the cracking of oil shall be free of particles of less than 20 microns in size. The spent catalyst is regenerated by oxygen containing gases passing through the regenerating zone at such a speed that those portions of the catalyst which are finer than 20 microns are levitated and discharged with the combustion gases, while the remaining portion of the catalyst is recycled to the cracking zone.

U.S.P. 2,432,822. Process for Thermal Preconditioning Catalyst in Hydrocarbon Conversion. R. B. Secor to Filtrol Corporation.

In the preconditioning of a cracking catalyst containing water removable by heating, e.g., a sub-bentonite catalyst, a relatively high density fluidized mass of catalyst and gas is maintained in a zone exterior of a fluidized catalyst stream circulating from a reactor to a regenerator and vice versa. Hot gas is passed through the exterior zone to condition the catalyst by gradually elevating the temperature thereof to about that to which the catalyst is subjected in the

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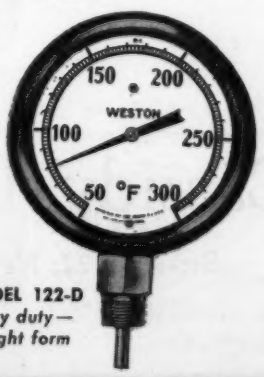

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cracking operation. The water is thus removed from the catalyst at such a low rate of heating that the catalyst remains unimpaired. The heat conditioned catalyst is then transferred in fluidized state from the exterior zone into the circulating stream.

U.S.P. 2,432,912. Catalytic Treatment of Hydrocarbons. H. D. Loeb to Shell Development Company.

This patent relates to the simultaneous catalytic treatment (e.g., cracking) of two hydrocarbon oils, each of which is cracked under different conditions with a fluidized finely divided catalyst having the same composition and the same range of particle size in both separate treating zones. The features of this separate treatment are described and claimed.

U.S.P. 2,432,962. Process for Heating Hydrocarbons by Contact with a Moving Granular Solid. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

This patent describes and claims features of a process according to which a mass of granular solid passes downwardly through a heating, a reaction, and a high temperature air preheating zone in series as a compact moving bed, while a second mass of granular solid passes downwardly through a low temperature preheating and quenching zone in series in a corresponding manner. A reactant mixture is contacted with the highly heated solid to induce the desired reaction, e.g., the cracking of heavier hydrocarbons to produce ethylene.

U.S.P. 2,433,603. Catalytic Treatment of Petroleum Hydrocarbons. P. S. Danner and R. C. Mithoff to California Research Corporation.

A liquid petroleum fraction boiling in the gasoline range is vaporized and passed through a treating zone while a metal oxide reforming catalyst, such as a mixture of aluminum, molybdenum and/or chromium oxides, or manganese dioxide, or zinc chromite, is passed through this zone in the opposite direction. The octane number of the hydrocarbon material is raised by this treatment and it is stabilized against gum formation or discoloration. The temperature in the treating zone can be controlled by introducing a gas into the hydrocarbon vapors at at least one point intermediate the ends of this zone.

POLYMERIZATION AND CONVERSION

U.S.P. 2,432,505. Catalysis of Hydrocarbons. R. E. Burk and E. C. Hughes to Standard Oil Company (Ohio).

A mixture of a normally liquid hydrocarbon fraction and a normally gaseous hydrocarbon fraction containing a normal hydrocarbon is reacted with a liquid HF catalyst containing not more than 50 percent of dissolved BF_3. The reaction is continued under conditions suitable for averaging the hydrocarbons and a pressure sufficient to maintain the HF in liquid phase. Hydrocarbons intermediate the normally gaseous and the normally liquid hydrocarbon fractions are produced and the normal hydrocarbon is isomerized. The isomerized hydrocarbon is separated and transferred

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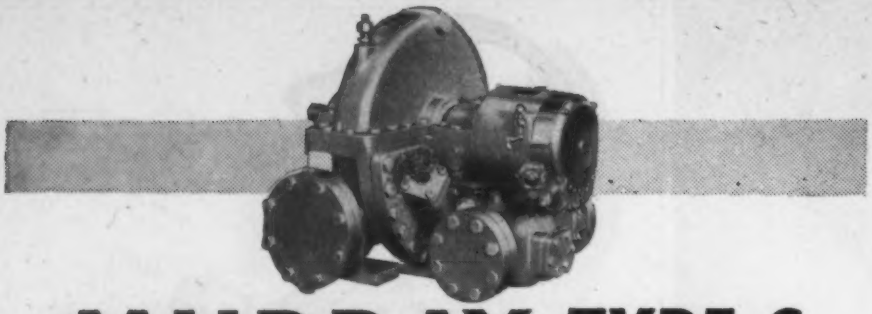

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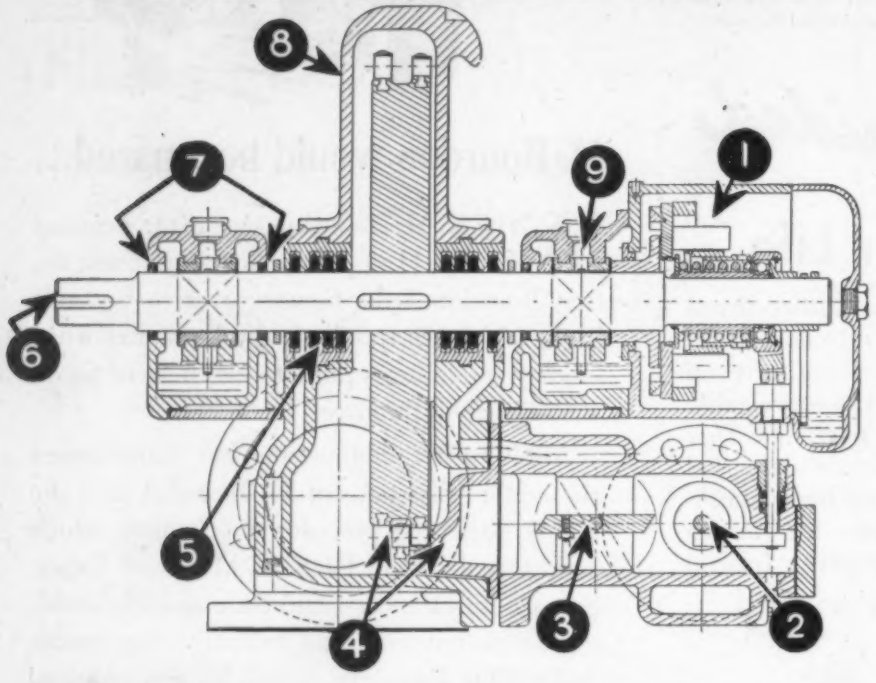

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to an alkylation zone together with the fluorides separated with it. At least part of the isomerized hydrocarbon is alkylated with an olefin in the presence of the above-defined catalyst comprising the fluorides from the averaging reaction. Hydrocarbons in the gasoline boiling range are obtained as the product of the process.

U.S.P. 2,432,745. Catalytic Conversion of Hydrocarbons. W. W. Gary to Filtrol Corporation.

This patent describes and claims a process for the catalytic conversion of hydrocarbons involving the use of a plurality of separate fluidized pools of granular catalyst and hydrocarbon vapors and gases.

U.S.P. 2,433,025. Low Temperature Polymerization Process. J. D. Calfee and R. M. Thomas to Standard Oil Development Company.

A mixture of a material containing a major proportion of isobutylene and a minor proportion of a conjugated diolefin with 4-10 C atoms, such as butadiene or isoprene, is polymerized in a continuous process at a temperature between —10° C. and —160° C. in the presence of a catalyst comprising $AlCl_3$ dissolved in an aliphatic halide with 1-2 C atoms. Ammonia, beta-naphthylamine or di-normal butylamine in an amount of 2-3 mols per mol of $AlCl_3$ present is added at intervals of 5-30 minutes to the continuous stream of the combined isobutylene-diolefin-catalyst mixture. This addition shall be sufficient to destroy substantially all catalyst and catalyst complexes, while an excess of the additive shall be avoided. No interruption of the stream of the combined mixture is then necessary and the temperature does not rise significantly. The addition of ammonia or the like is always completed at a time interval of a few minutes. The frequency of the additions is determined by the thickness of overflow material from the polymerization reaction. A very uniform polymer of desired quality is obtained by this process while the formation of undesired types of polymer is avoided.

U.S.P. 2,433,045. Recovery of Polymerized Olefins. J. P. Hamilton to Carbide and Carbon Chemicals Corporation.

In a continuous gas-phase polymerization of olefins, e.g., ethylene, to solid polymers under pressures exceeding 500 atm. and at temperatures above 100° C., the unreacted gas and polymer are discharged directly from the reaction zone into a vessel closed to the atmosphere and adapted to permit separation of the gas from the polymer and a gas expansion to a pressure of 100-1000 psi. The polymerized product is kept in this vessel in a plastic state by maintaining a temperature in the gas of 125-300° C. The polymer is continuously extruded under pressure of the unreacted gas into a dense compact product resistant to deterioration on subsequent handling and fabrication.

U.S.P. 2,433,070. Method for Producing Synthetic Rubberlike Polymers. W. J. Sparks and J. D. Calfee to Standard Oil Development Company.

The patent describes and claims a process for copolymerizing at low temperature 70-99.5 parts of isobutylene and 30-0.5 parts of a conjugated diolefin with 4-10 C atoms in a liquid bath in the presence of solid CO_2. A Friedel-Crafts catalyst is employed for copolymerizing

the mixture cooled by circulating through the solid CO_2.

U.S.P. 2,433,345. Cyclic Catalytic Process. L. W. T. Cummings to Houdry Process Corporation.

The cyclic hydrocarbon conversion process according to this patent involves a plurality of contact material containing converters some of which are on steam while others are maintained under regenerating conditions. A portion of the heat evolved in regeneration is stored in zones with higher heat capacity than the contact material. The excess heat is removed by an oxygen containing cool gas which is in direct heat exchange with the contact material. The hot gas is supplied to a converter in which the on-stream reaction is completed in direct contact with the contact material therein in order to raise the temperature and initiate the regeneration reaction.

U.S.P. 2,433,372. Method of Making a Solid Dimer of Alpha-Methyl Para-Methyl Styrene. B. H. Kress to Federal Telephone & Radio Corporation.

Alpha-methyl para-methyl styrene is heated under agitation to a temperature of 200-250° C. in the presence of a clay-type catalyst, such as activated diatomaceous earth, Fullers' earth, or floridin. The solid dimer of said compound is obtained. It can also be produced by subjecting the liquid dimer to the treatment described.

U.S.P. 2,433,670. Catalytic Reaction Apparatus. E. Kropp to Standard Oil Company (Ohio).

The apparatus according to this patent is designed for the catalytic treatment of hydrocarbon gases, e.g., their dehydrogenation, aromatization, or the like, and for the alternative regeneration of the catalyst. Features of the apparatus are described and claimed which permit great simplification of connections and valve control equipment.

U.S.P. 2,433,726. Apparatus for Contacting Fluids with Subdivided Solids. C. H. Angell to Universal Oil Products Company.

The invention relates to an apparatus designed to effect contact between fluids and subdivided solids, particularly suited for use in the conversion of fluid hydrocarbons in contact with subdivided catalyst and for the regeneration of catalyst. The conversion reaction and the regeneration are accomplished simultaneously in separate confined zones through which the catalyst material is circulated.

U.S.P. 2,433,798. Catalytic Hydrocarbon Conversion Process and Apparatus Therefor. V. Voorhees to Standard Oil Company (Indiana).

The patent relates to a catalytic conversion process wherein the powdered catalyst is suspended during the reaction period as well as during the regeneration period in up-flowing vapors or gases. The vertical vapor or gas velocity in one of the up-flowing streams is regulated to permit agglomerated catalyst particles to settle so that they can be withdrawn from the base of the chamber of that up-flowing stream. The agglomerated particles are pulverized and then reintroduced into the system.

U.S.P. 2,434,202. Method and Apparatus for Contacting Gases with Particle Form Solid Contact Materials. L. P.

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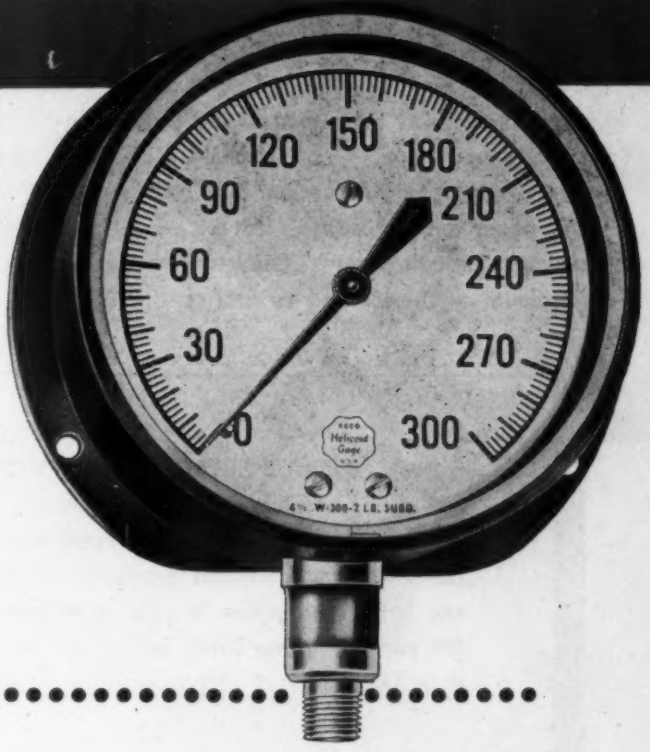

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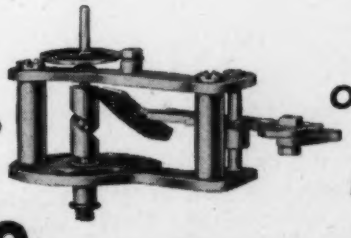

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Evans, C. V. Hornberg, and F. E. Ray to Socony-Vacuum Oil Company, Inc.

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HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,432,843. Process for Hydrogenating Mononuclear Aromatic and Cycloalkene Hydrocarbons. G. M. Whitman to E. I. du Pont de Nemours & Co.

Mononuclear aromatic and cycloalkene hydrocarbons are ring hydrogenated to form the corresponding saturated cycloaliphatic hydrocarbons by contacting hydrogen with an aromatic or cycloalkene hydrocarbon in the presence of anhydrous ammonia and an alkali metal or alkaline earth metal as the catalyst at a temperature in excess of 50° C. (preferably at 100-400° C.) and under a hydrogen pressure of at least 100 psi. (preferably 1000-15,000 psi.) The presence of a small amount of ammonia enhances the catalytic activity of said metals.

U.S.P. 2,433,072. Method of Effecting Catalytic Reaction Between Carbon Monoxide and Hydrogen. M. M. Stewart, R. C. Garrett, and E. E. Sensel to The Texas Company.

The patent relates to a continuous process for reacting CO with H_2 at a temperature of 250-750° F. and a pressure in the range of atmospheric and substantially above. A stream of an inert liquid non-vaporizable under reaction conditions is saturated with gas under a pressure substantially higher than that used in the reaction. A slurry of powdered solid catalyst in hydrocarbon is brought to contact with said saturated stream and the latter is expanded within the reaction zone so that it is filled with a continuous mass of foam containing catalyst powder suspended therein. CO and H_2 are continuously passed through the reaction zone in contact with this foam. A mixture of foam, catalyst and reaction products is withdrawn from the upper portion of the reaction tower. The process is said to be superior to the Fischer-Tropsch process as previously used by permitting the employment of a less complicated and less expensive reactor of higher capacity for a given volume, and by allowing an easier temperature control.

U.S.P. 2,433,255 Method for Synthesizing Hydrocarbons and the Like. H. V. Atwell to The Texas Company.

The patent relates to the exothermic conversion of gaseous reactants, particularly a mixture of CO and H_2, in the presence of a particle form catalyst arranged in a series of separate stages within the reaction zone. Each stage comprises a lower bed of catalyst and an upper bed of non-catalytic contact material in particle form. Each of the catalyst beds is in direct contact with a liquid coolant which is partly vaporiz-

able under the conditions prevailing within this bed. An effluent comprising conversion products, unconverted reactants and vaporized coolant passes to the next higher non-catalytic bed in each stage. Non-vaporized coolant is withdrawn from each stage and returned to each stage at a point above the upper bed of non-catalyst material so that it passes downwardly through this bed in countercurrent contact to the effluent from each catalyst bed, scrubbing the rising effluent. The higher boiling components of the effluent including vaporized coolant are condensed. A gas oil fraction obtained from the products of the gas conversion can be employed as the coolant.

U.S.P. 2,433,800. Production of Butadiene. C. C. Watson to Universal Oil Products Company.

N-butane is subjected to partial catalytic dehydrogenation to n-butylene and butadiene in a first dehydrogenation zone. The yield of butadiene is 10-30 vol percent of the n-butane charged. The n-butylene is separated from the resultant products and catalytically dehydrogenated in a second zone to form further amounts of butadiene. An alumina-chromia catalyst can be used in the first zone and a composite of a major proportion of MgO and minor proportions of Fe_2O_3, CuO, and K_2O as the catalyst in the second zone.

ALKYLATION

U.S.P. 2,433,020. Catalytic Alkylation of Aromatic Hydrocarbons by Paraffins. S. B. Becker to Standard Oil Company (Indiana).

An aromatic hydrocarbon and a paraffin are contacted with a catalyst which consists essentially of HF and 2-20 percent by weight of BF_3 at conversion temperature, e.g., 200-400° F. The pressure shall be sufficient to maintain liquid phase conditions during the conversion. An alkyl aromatic hydrocarbon and an isoparaffinic hydrocarbon are formed and separated.

U.S.P. 2,433,944. Method for Continuously Reacting Saturated Tertiary Hydrocarbons and Olefins. A. A. Draeger and C. T. Shewell to Standard Oil Development Company.

In the continuous alkylation of isoparaffins with olefins in the presence of a liquid catalyst of greater density than the hydrocarbons treated, e.g., H_2SO_4 of high concentration, feed hydrocarbons and catalyst are continuously introduced to a vertical reaction vessel while a stream of mixed catalyst and hydrocarbon is continuously withdrawn from the upper portion of this vessel. A diverted portion of this stream is recycled to the lower portion of the vessel in such amount and with such velocity of flow as to impart substantial agitation to the reactants in the vessel. The non-diverted portion of the withdrawn stream is separated by settling into alkylated hydrocarbons and catalyst.

U.S.P. 2,434,000. Production of Motor Fuel. M. P. Matuszak to Phillips Petroleum Company.

Normal 2-olefin is separated from a mixture of normal 1-olefin and normal 2-olefin, e.g., butene-1 and butene-2. The residual 1-olefin is converted to alkyl

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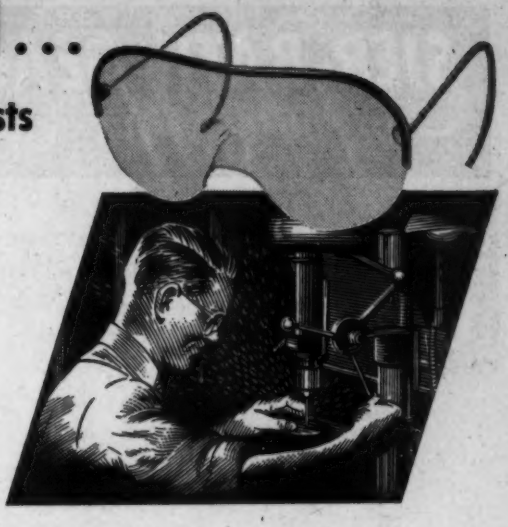

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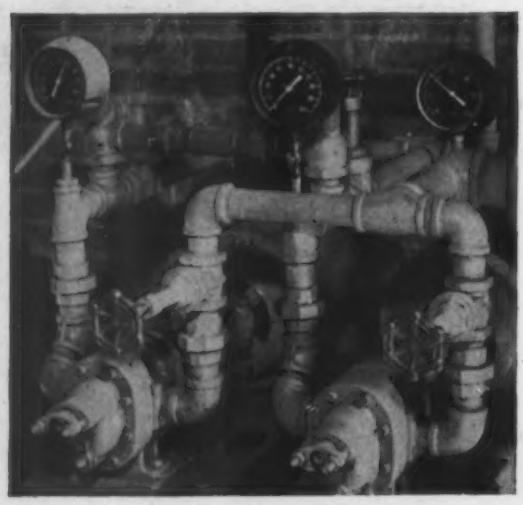

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fluoride. The latter and the separated 2-olefin are combined and reacted with a low-boiling isoparaffin under alkylation conditions in the presence of a HF catalyst. Paraffinic hydrocarbons produced are recovered.

ISOMERIZATION

U.S.P. 2,433,079. Catalytic Isomerization Process. J. M. Whiteley, Jr., and C. S. Lynch to Standard Oil Development Company.

A continuous circulating stream of normal paraffin with at least 4 C atoms in liquid phase containing hydrogen halide is percolated through a bed of $AlCl_3$ in a reaction zone under isomerizing conditions. The isoparaffin formed is recovered from the reacted mixture. The catalyst is preferably in the shape of granules and the preferred temperature is between 40° and 300° F.

U.S.P. 2,433,482. Method for Preventing Build-up of Light Gases in a Paraffin Isomerization Process. J. K. Roberts to Standard Oil Company (Indiana).

This patent describes and claims particulars of a process for converting hydrocarbons, e.g., for isomerizing hydrocarbons with at least 4 C atoms, in the presence of aluminum halide activated by a hydrogen halide. Undissolved gases including hydrogen halide are separated from the reaction products and dissolved gases are stripped therefrom.

DESULFURIZATION

U.S.P. 2,433,426. Desulfurizing Adsorbent and Process for Preparing Same. R. G. Capell and R. C. Amero to Floridin Company.

For preparing a desulfurizing adsorbent for hydrocarbon gases and liquids, iron oxide in an amount of 70-90 percent is mixed with 30-10 percent of Fuller's earth containing a sufficient quantity of its natural water of hydration to preserve its gelling properties. The mixture is plasticized, extruded and heated at a temperature of 230-1400° F. to activate the mass.

HEAVY OILS AND WAXES

U.S.P. 2,432,806 } 2,432,807 } Petroleum Oil Compositions. A. G. Rocchini and C. B. Pattinson, Jr., to Gulf Research & Development Company.

The composition according to patent 2,432,806 comprises a major amount of a petroleum lubricating oil and a small amount (e.g., 0.25-2.0 percent) of orthoethylphenol. The additive retards chlorination of the lubricating oil, for example when the oil is employed in gas compressors and vacuum pumps used to handle chlorine containing gases.

According to patent 2,432,807 orthocyclohexylphenol is employed as the additive for the same purpose.

U.S.P. 2,432,901. Rust Inhibiting Oil Composition. S. C. Johansson.

The composition according to this patent comprises an oil of mineral or vegetable origin, an alkali metal salt of a nitrophenol normally insoluble in the

oil and amylalcohol as a solvent for the salt. The additive inhibits corrosion by the oil.

U.S.P. 2,433,636. Manufacture of Greases. B. H. Thurman to Benjamin Clayton (Refining Unincorporated.)

The patent describes and claims details of a continuous process for making grease from lubricating oil and an insoluble polyvalent metal soap.

U.S.P. 2,433,797. Manufacture of Lubricating Oil. F. C. Toettcher to The Texas Company.

Raw lubricating stock obtained from crude petroleum is first refined by acid treatment and solvent refining and contacted with a composite of molybdenum oxide and alumina at a temperature of 650-750° F. Increased oxidation stability of the oil results from this treatment.

U.S.P. 2,433,851. Pour Point Depressant. E. Lieber to Standard Oil Development Company.

Waxy mineral lubricating oil contains a small amount, e.g., 0.1-5 percent of a pour point depressing additive formed by the condensation of a lower aldehyde with not more than 8 C atoms and of the general formula RCHO in the presence of 0.1-1 mol of a Friedel-Crafts catalyst in an inert solvent at a temperature of 50-300° F. The high mol wt. condensation product thus obtained is soluble in mineral oils and is substantially non-volatile under reduced pressure at temperatures up to 500° F. In the above formula R can be an alkyl or an aryl hydrocarbon radical. The autocondensation product of benzaldehyde can, for example, be employed as the pour-depressing additive.

U.S.P. 2,433,852. Condensation Product and Preparation and Use Thereof. E. Lieber to Standard Oil Development Company.

This patent is similar to 2,433,851. In the present case the condensation product employed as the pour-depressing additive is produced by condensing in a corresponding manner 5-20 moles of a lower saturated alkylene glycol with less than 10 C atoms, such as ethylene glycol, with 1 mole of a condensable aromatic hydrocarbon with 6-12 C atoms, such as naphthalene.

U.S.P. 2,433,853. Sulfurized Oils. B. H. Lincoln and W. L. Steiner to The Lubri-Zol Development Corporation.

The patent relates to a lubricant which comprises a major proportion of an oil of lubricating viscosity and a minor proportion of a halogen-bearing sulfurized ester of a phenol and an unsaturated organic acid, such as halogenated sulfurized phenyl oleate or linoleate. The film strength of the oil is increased by this additive.

U.S.P. 2,433,861. Grease Composition. G. M. McNulty and J. C. Zimmer to Standard Oil Development Company.

The anhydrous, high temperature reversible grease composition according to this patent comprises a mineral lubricating oil and a soap. The latter is the reaction product of a soap stock and a polyvalent metal hydrate heated to a temperature of 400-500° F. An addition of 0.1-5 percent of HCl or a polyvalent metal halide is incorporated as a water insoluble integral part of the soap before

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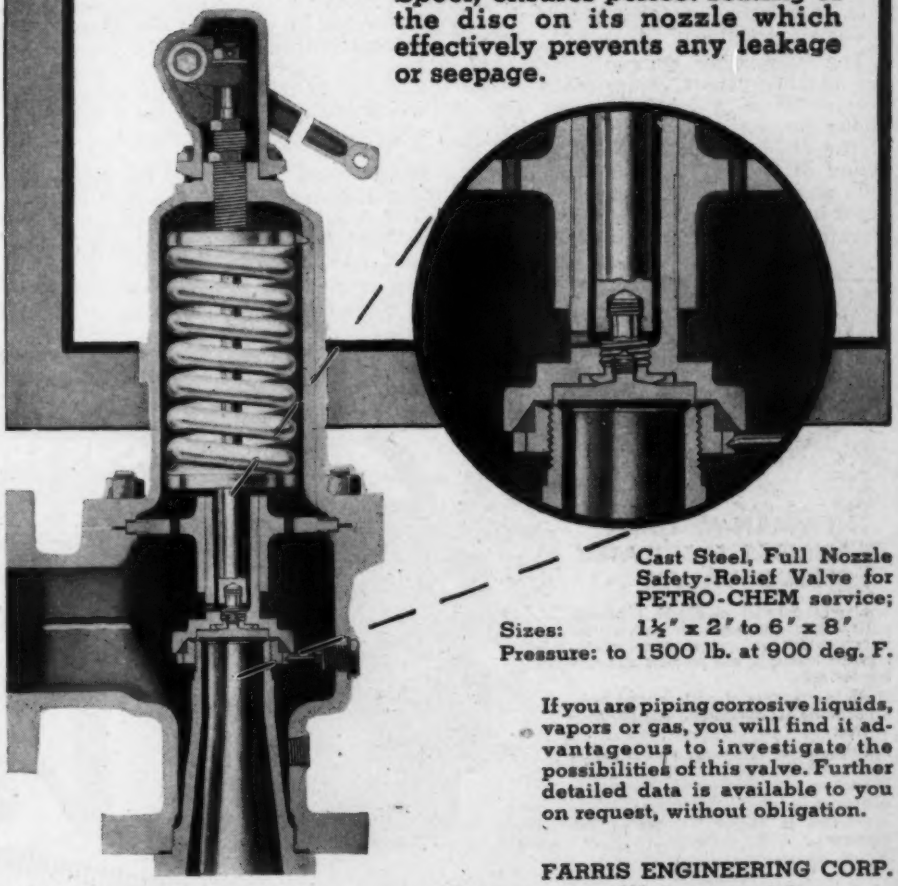

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or during the formation of the polyvalent metal soap. It effects a raise of the reaction temperature of formation of the soap substantially above the usual reaction temperature. The dropping point of the grease is greatly raised by the halide containing material.

U.S.P. 2,434,113. Selective Adsorption of Lubricants. H. W. F. Lorenz.

In order to extract oiliness agent, i.e., the constituent which spreads as a film between two metal surfaces and is adsorbed in the pores of the metal, from a lubricating oil, such as a high boiling, high mol. wt. paraffin oil, a solid metal with a m.p. below 200° C. is wetted with the lubricating oil to impregnate and coat the metal surface with oil. The unattached oil is then separated from the metal and the metal is melted to set free the attached oiliness agent which is recovered by gravity separation. The oiliness agent thus obtained may be used as an additive or blending agent with other lubricants to build up an effective film for the reinforcement of the lubricants used.

U.S.P. 2,432,713. Composition Containing Higher Condensation Products of Aldehydes and Aromatic Amines. J. D. Bartleson to The Standard Oil Company (Ohio).

The lubricating composition according to this patent comprises a major proportion of a lubricating oil and a minor amount of an additive consisting of the condensation product of the reaction of about 1 mol of formaldehyde with about 2 mols of N-ethyl aniline reacted in an aqueous acidic solution at an elevated temperature. This product boils above 262° C. at 9 mm. Hg absolute pressure and is separated from any condensation product boiling below that point. The lubricating composition obtained is stabilized by the additive, is markedly lower in corrosive properties than the lubricating oil employed, and is particularly adapted for use in lubricating internal combustion engines containing copper-lead bearings.

PETROCHEMICALS

U.S.P. 2,432,532. Production of Acetonitrile. J. E. Mahan to Phillips Petroleum Company.

A 3-5 C atom aliphatic monoolefin is reacted with ammonia in the vapor phase in the presence of alumina catalyst at a temperature of 1100-1200° F. and at a pressure of from atmospheric to 100 psi. Propylene, butene-1, or isobutene can, for example, by employed as the monoolefins.

U.S.P. 2,432,686. Manufacture of Resins from Sulfur Dioxyde and Unsaturated Organic Compounds. A. K. Scribner and F. W. Wilder to Phillips Petroleum Company.

A mixture of olefins containing 42-58 percent by weight of propylene, 28-33 percent butene-2 and 14-19 percent butene-1 is reacted with SO_2 at a temperature of 95-115° F. Resins are obtained which are very satisfactory as to clarity and molding characteristics.

U.S.P. 2,433,182. Process for Production of Unsaturated Nitriles. I. L. Wolk to Phillips Petroleum Company.

Vinylacetylene is cracked at a temperature of 400-650° C. in the presence of hydrogen cyanide and a catalyst comprising an alkaline earth metal cyanide supported on a cracking catalyst, such as Al_2O_3. 1-2 mols of hydrogen cyanide can be used for one mol of vinylacetylene.

U.S.P. 2,433,419. Method of Chlorinating Paraffin. P. Bosko to Hercules Powder Company.

Gaseous chlorine is passed into molten paraffin wax, the temperature of which is permitted to rise above 100° C., until a chlorine content of 10-60 percent is obtained in the chlorinated wax. The temperature is then lowered to a point at which no decomposition occurs while the introduction of chlorine is continued, though at a reduced rate. This introduction is discontinued when the lower temperature desired is reached, whereupon the product is air-blown at this temperature to remove free chlorine and HCl. A chlorinated paraffin wax is obtained.

U.S.P. 2,433,646. Solube Oil and Process of Producing Same. P. L. Carter and W. J. Coppock to Sun Oil Company.

A mixture of naphthenic acids and lubricating oil is treated with a sulfonating agent, e.g., H_2SO_4, under suitable conditions, e.g., at a temperature of 150-250° F., to form a sulfonated stock. This stock is neutralized with an alkali metal hydroxide to form a soluble oil.

U.S.P. 2,434,092. Production of Alkyl Chlorides. W. N. Axe to Phillips Petroleum Company.

An olefin is reacted with anhydrous HCl in the presence of a catalyst com-

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prising a BF_3 addition product formed by saturating ortho-phosphoric or phosphorous acids with BF_3. This catalyst catalyzes the addition reaction of HCl and olefin under very mild reaction conditions, e.g., at a temperature of 32-150° F.

U.S.P. 2,434,093. Hydrochlorination Process. W. N. Axe to Phillips Petroleum Company.

The process of this patent is similar to that of patent 2,434,092. In the present case the catalyst comprises an addition product of BF_3 and water in which at least 1 mol of water is present for each mol of BF_3. Water completely saturated with BF_3 can be used for this purpose.

U.S.P. 2,434,094. Hydrochlorination of Olefins. W. N. Axe to Phillips Petroleum Company.

A continuous process for the production of alkyl chlorides from aliphatic olefins and HCl in the presence of a solid catalyst material, such as $AlCl_3$ adsorbed on a coarse granular carrier, is described. The HCl coming from a stripping zone is passed upward through a vertical reaction zone packed with the catalyst material, while the olefin together with an inert diluent, such as n-pentane, is introduced at a plurality of vertically spaced points into this zone.

Business Economics Primer Published by Shell Oil

Publication of a new booklet, "intended to clarify the principles of the American economic system and the operation of modern corporate business," was announced last month by Shell Oil Company, Inc. Entitled "Pete is a Prime Mover," the booklet employs a combination of lively illustrations and brief text blocks to tell its story. It will be distributed not only to Shell employes and dealers, but to business leaders, educators, government officials, and others interested in broadening popular understanding of the workings and benefits of industrial enterprise.

Using the oil industry as an example, "Pete" reveals the part played by shareholders in business, and then traces how the income of a typical corporation is divided and spent. Finally, the groups who benefit from our economic system are enumerated, including the consumers, employes, stockholders, supplier organizations, government, local communities, and the public as a whole.

New Date Is Set for AIC

The date of the annual meeting of The American Institute of Chemists has been changed from May 8 to Friday, May 7, the change being made to enable the New York Section of ACS to meet jointly at the Institute's silver anniversary dinner at the Waldorf-Astoria Hotel, New York. At that time, the Institute will present its gold medal to Dr. Charles Allen Thomas, ACS president who will combine his acceptance speech with his previously scheduled address before the ACS group on May 7.

Straight Retires

H. R. Straight, chairman of the board of Cities Service Oil Company, late last month announced his retirement after 36 years with the company. He will retain a place on the board but will not be active in the business. Farming and cattle raising will engage his attention.

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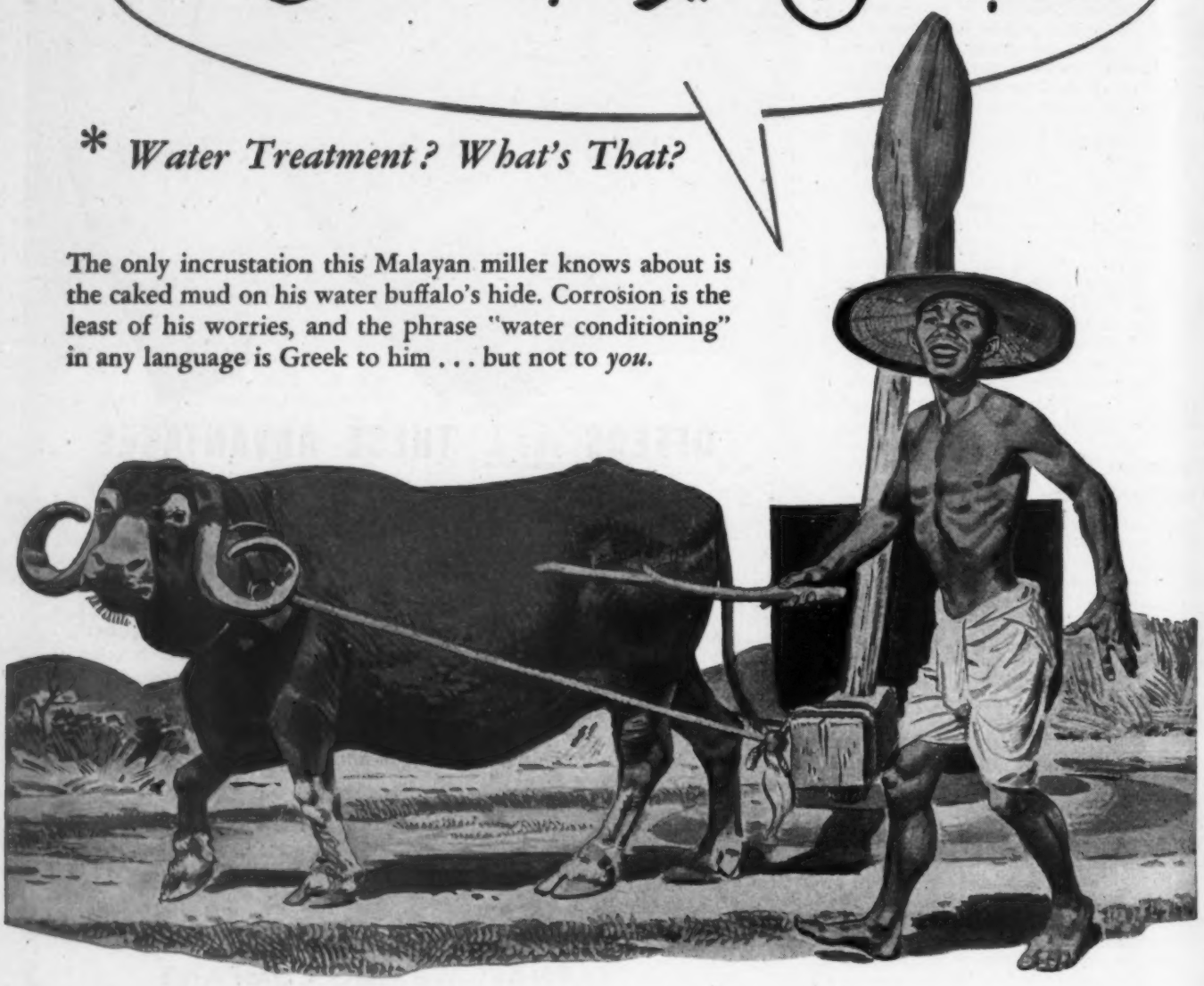
SECOND—Screen cap is made with straight thread, machined face and spark plug gasket, insuring tight joint. Screen comes out with cap for easy cleaning . . . automatically aligns when replaced.
THIRD—Iron and steel bodies are cadmium-plated for protection against corrosion and for better appearance.
FOURTH—Available in six sizes, from ½" to 2" for pressures to 600 lbs.
FIFTH—Reasonably priced.
SIXTH—Stocked and sold by 150 Mill Supply Houses. Hundreds of thousands already in use. See your local dealer or write for Bulletin S-201.
YARNALL-WARING COMPANY
128 MERMAID AVENUE PHILADELPHIA 18, PA.
YARWAY STRAINERS
"Police the Pipelines"

مغبا تکن آیر اپاه این ؟ *

* *Water Treatment? What's That?*

The only incrustation this Malayan miller knows about is the caked mud on his water buffalo's hide. Corrosion is the least of his worries, and the phrase "water conditioning" in any language is Greek to him . . . but not to *you.*



THE BIRD-ARCHER 8-POINT WATER TREATMENT SERVICE

1. *Study of all available water sources*
2. *Plant Survey*
3. *Laboratory Service for scientific analysis*
4. *Development of treatment and control systems*
5. *Instructing plant staff in the operation and control of the treatment system*
6. *Furnishing properly prepared treatment materials*
7. *Specifying any equipment necessary*
8. *Regular check-ups by service engineers*

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Whether you use water for processing or cooling, or to generate steam, you will be interested in knowing how Bird-Archer can solve your water conditioning problems ... reduce operating costs, increase efficiency, and lengthen the life of your water and steam handling equipment.

Bird-Archer has been successfully treating water for industry for over 60 years, and offers a complete 8-point service. For full details, ask to have a Bird-Archer field engineer pay you a visit. No obligation.

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New EQUIPMENT MANUFACTURERS' LITERATURE

FOR COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES. USE THE NUMBER SHOWN FOR EACH ITEM AND THE ADDRESS LISTED

1—Cleaners

Airetool Manufacturing Company, 316 South Center Street, Springfield, Ohio, has called attention to the erroneous use of a photograph of its new Model CC-375 geared cleaner in connection with a description of the Model CC-450. (January Refiner, p. 198).

Model CC-375 is designed to meet the demand for an efficient condenser and heat exchanger tube cleaner "powerful enough to cut through the heaviest scale yet light in weight." (The motor weighs only 35 pounds). The unit, made of sturdy aluminum alloy, "will clean any type of scale in tubes ⅜ to 1¾ inches i.d. and will thoroughly clean tubes completely closed with scale."

All moving parts are made from alloy-steel and it is powered by an air or steam driven motor that has a maximum of 1200 rpm. A variety of drills and cutting edges may be used.

Model CC-450, previously described, is a direct-drive cleaner which weighs only 21 pounds which can be used with or without a supporting rig.

2—Carbon Arc Torch

The Lincoln Electric Company, Cleveland 1, Ohio, has announced a new low-price carbon arc torch for use with AC welding machines. It is of rugged yet lightweight construction, designed to extend the use of welding equipment to jobs where the application of heat is desired without melting the metal being worked on. A high-temperature flame is produced between two copper coated carbon electrodes clamped in aluminum alloy jaws. Both carbons are readily adjustable, geared to move together so that the angle of the carbons can be kept constant at all times. The handle of the torch is provided with simple geared thumb control tabs. The torch is equipped with two cable leads, one with a tip that is clamped to the welder's regular electrode holder, and the other with a spring clip that clips to the welder's ground lead. The handle is made of rugged thermal plastic.

Lightweight Carbon Torch

3—Relay

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has added a new micro sensitive relay to its line of D. C. amplifiers. The model 143X, utilizing

the "Microsen balance" principle, provides a full output change of 5 milliamperes for a 2 micro-ampere input change, and is equipped with a mechanical range adjustment for setting the operating point at the desired input level. This unit is designed particularly for use as a component of other electronic or electromechanical apparatus.

4—Slide Rule

A new slide rule, designed by Tube Turns, Inc., 224 East Broadway, Louisville 1, Ky., and called the "Tube-Turn velocity and pressure drop calculator," gives two kinds of answers to fluid flow problems: 1) a quick estimate based upon a pipe friction factor of 0.006, and 2) an accurate solution, derived from the estimate by applying a correction factor to the straight pipe losses. The fitting and valve losses are independent of the friction factor and therefore require no correction.

One part of the rule is devoted to liquids and another to gaseous fluids. Due to compressibility effect, the calculator will not give accurate solutions for gaseous fluids where the pressure drop exceeds 10-15 percent of the initial pressure.

5—Oil Tank Coating

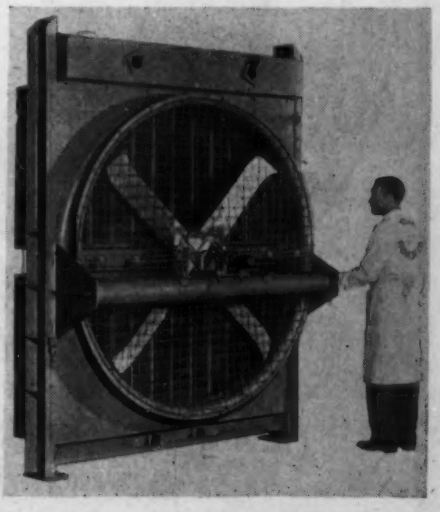
"Coro-Gard," a coating product for the protection of steel against the corroding action of sour crude, salt water, and acetic salt solutions, announced by Minnesota Mining & Manufacturing Company, 900 Fanquier Avenue, St. Paul 7, consists of a synthetic resin base, a powdered mica gray pigmentation, and a solvent, methyl-isobutyl-ketone and butyl acetate. Application is by conventional spray, brush or mop, and involves no activators, heat cures or primers.

The coating "will prevent corrosion of steel tanks in sour crude fields for at least two years, probably four, and possibly longer," the producers claim. During such a service life, the coating in some instances would require retouching at about two-year intervals. Application requires 48 to 96 hours for an average tank, including cleaning, spraying on three coatings, and complete curing. A brochure is available.

6—Radiator

Young Radiator Company of Racine, Wis., has developed a new type radiator known as the "Mono-Weld," said to have many advantages for heavy-duty gasoline, gas and diesel engine applications. Claimed "stronger and more efficient" than its predecessors, the new Mono-Weld line covers a complete range of sizes from the smaller units, approximately 2½ feet square, in graduated sizes up to the larger units, approximately 10½ feet square.

Innovations of this line as exemplified by one of the larger radiators, include fabricated steel-headers, formed steel side members and seamless tubes brazed

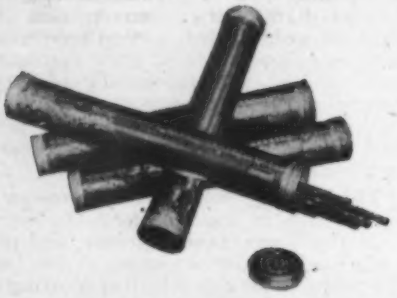


Rear View, Mono-Weld Radiator

to heavy header plates. This unit also has an aerodynamically-designed fan with variable pitch, which can be adjusted for temperature and climatic changes. Either a pusher or puller fan can be used. Heavy steel formed and welded shutters are used to insure better control of the cooling process.

7—Electrodes

A new group of hard-surfacing electrodes is announced by Harnischfeger Corporation, Welding Division, 4400 W. National Ave., Milwaukee 14, Wis. Named "Hartop" there are four electrodes in this new P&H series covering the Rockwell C range of from 35 to 63 (as deposited). A feature is "their easy, stable arc," the manufacturer claims.



"Weld metal flows quietly and smoothly and there is no slag to remove."

P&H also has introduced a new method of packaging, each Hartop type being in specially designed 5-pound moistureproof tubes having air-tight, screw-on tops.

8—Flux Injection Cutting Torch

Air Reduction Sales Company, 60 East 42nd St., New York 17, has announced a new hand torch for cutting stainless steel using Airco's flux-injection process. Designated in its 21-inch length as Style 9016, the torch is also available in a 36-inch length. Both lengths come with a 90° torch head. This torch, which was subjected to extensive field trial befor it was put on the market is similar in many respects to the familiar Airco Series 9000 cutting torch. Featured are a monel metal head, stainless steel tubes, stainless steel lever and ribbed handle and remote control cut-off.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

9—Solenoid Valve

A new solenoid valve has been perfected by Waterman Engineering Company, 721 Custer Avenue, Evanston, Ill., for all hydraulic systems, or for the handling of any non-corrosive fluids. It has a maximum working pressure of 3000 psi. and electrical requirements of 6, 12, 24, or 36 volts D. C. It locks the fluid in one direction and admits free flowing in the other direction. This valve is also available with integral flow rate regulation.

10—Steam Trap

A new steam trap, "small in size but having a comparatively large capacity," has just been announced by Wright-Austin Company, 315 W. Woodbridge St., Detroit. The trap is designed for unit trapping installations draining steam heated equipment. Valves are accessible through an outside connection and may

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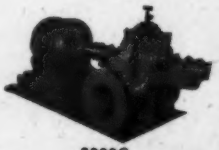
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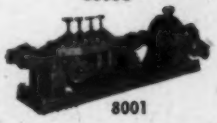
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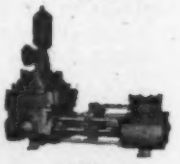
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BRANCH OFFICES

NEW YORK HOUSTON

STOP HIGH TEMPERATURE THREAD GALLING AND COSTLY STUD BREAKAGE!

New C-5

"HI-TEMP" Thread Compound—
proven in world's largest refineries — minimizes shut-down and dismantling time

*Colloidal Copper

FREE TEST SAMPLE
Yours for the asking

"Stud breakage practically eliminated"—
"Great reduction in removal time"—
"Substantial savings in labor costs"—

—That's what an enthusiastic major oil refinery has to say about its experience with completely new FEL-PRO C-5 HI-TEMP Thread Compound. Some of the world's largest refineries have tested and standardized on HI-TEMP for use on installations where high temperatures are encountered.

HI-TEMP is a colloidal-copper compound for use on all threads, flanges and fittings subjected to temperatures up to 1800° F. It eliminates all galling of threads and breakage of studs, bolts and flanges. Easy to apply, HI-TEMP provides a positive seal, while reducing friction to a minimum. It will not corrode steel, including stainless and other alloys.

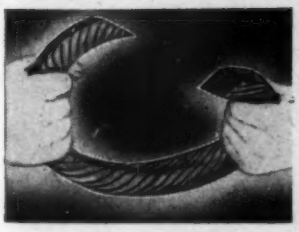
Furnaces with heater plugs and studs, which formerly required several days to dismantle, are now dismantled in a matter of hours, where HI-TEMP has been applied. HI-TEMP is especially adapted for inside vessel bolts, reactors, regenerators, fractionators, surge blocks, threaded-type pump sleeves —and, in general, all junctions of metal surfaces which undergo extreme temperatures and pressures.

As it has for others, HI-TEMP will minimize *your* shut-down and dismantling time, and decrease your operating costs. We invite you to use our free sample to make your own test—the trial will convince you!

FELT PRODUCTS MFG. CO.

30th ANNIVERSARY YEAR

2692



Refinery Packing

Especially designed packings for general oil-proof, petroleum and steam services.

Felt Products' aluminum and babbitt foil packings are engineered for every refinery use. Their success is due to resiliency, and a direct result of "twisted" construction and the sealed-in Colloidal Metal Lubricant. This exclusive colloidal lubricant provides a metallic carbon bearing surface which minimizes friction. It does not readily wear off, as it forms an integral part of the packing.

For Your **FREE** sample, *Clip Coupon TODAY*

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☐ Please send me a sample can of HI-TEMP, postage prepaid, with no obligation on my part. ☐ Also, data on your Recommended Packing for _____

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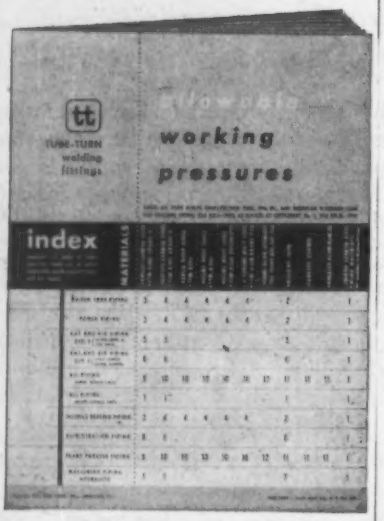
is a

Welding Fitting



GET THIS BOOK

Allowable Working Pressures: This book of pressure tables is a real working tool. Covers Tube-Turn welding fittings in all sizes, all weights, and all regularly manufactured materials, for Power, Oil and Chemical Process, District Heating, Gas, Refrigeration, and Hydraulic Piping. Mail the coupon.

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be changed for various pressures with other adjustments. Valves and seats are interchangeable in the full range of the trap sizes with a common pressure range. The maximum pressure for which the trap is recommended by the manufacturer is 125 psi. When inspection is desirable, the body of the trap may be unbolted and removed without disturbing pipe connections, exposing internal parts for examination.

12—Remote Control Crane

A feature of the new P&H truck cranes, manufactured by Harnischfeger Corporation, 4400 W. National Avenue, Milwaukee 14, Wis., is remote control which provides the crane operator with full control of the carrier from the crane cab, all normal carrier operations being controlled by simply pushing buttons. These truck cranes have one engine for travel and another for crane service. This permits faster moves from job to job, with road travel at truck speeds. Other features of this truck crane are: hydraulic control, independent planetary boom hoist, planetary load lowering and all-welded construction.

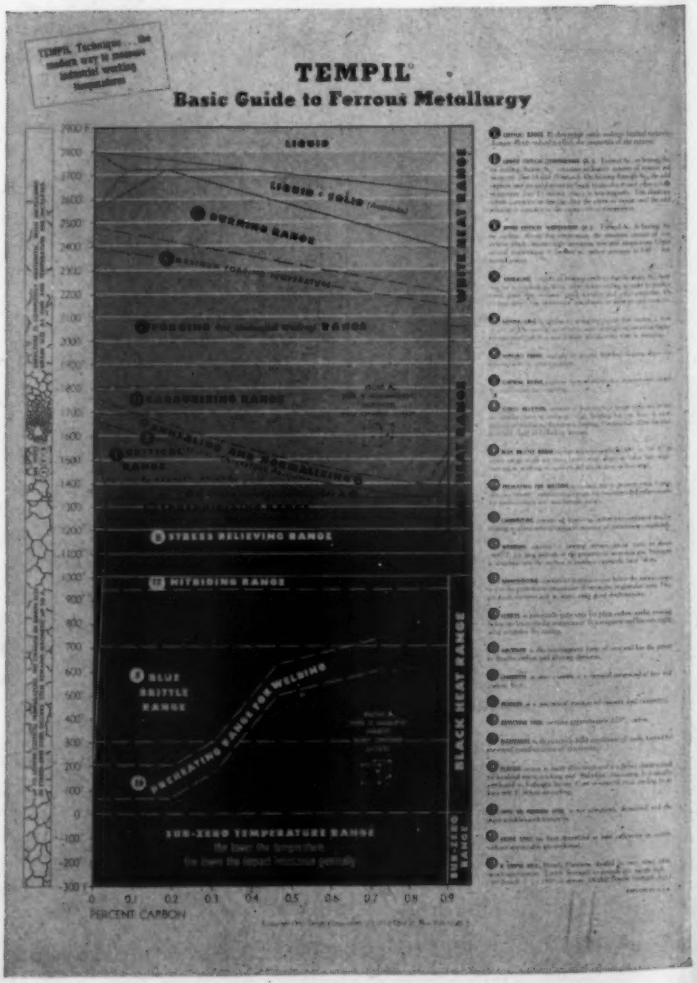
13—Silicone Rubber Gaskets

GE silicone rubber gaskets that do not adhere to metal, withstand temperatures as high as 400° F. and maintain their original characteristics under high vacuum are now being incorporated in chemical reactors used in the manufacture of GE Glyptal alkyd resins, General Electric Company, Pittsfield, Mass. has announced.

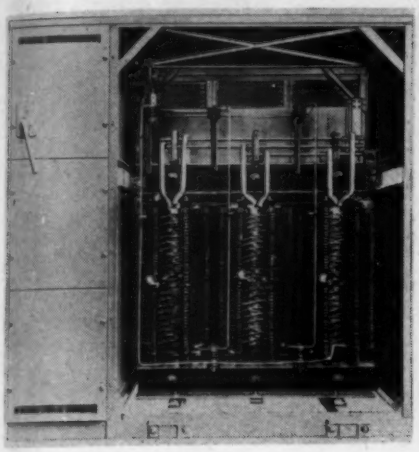
Providing excellent resistance to alcohol, phenol, aromatic hydrocarbons, and other solvents, the material is particularly effective for use as a gasket material in the processing of these materials because of the absence of a plasticizer in the silicone rubber stock, it was said.

11—Basic Guide to Ferrous Metallurgy

A "Basic Guide to Ferrous Metallurgy," printed by Tempil Corporation, 132 West 22nd Street, New York 11, shows the working characteristics of steels at temperatures from minus 300° F. to 2900° F. All the important temperature zones are clearly defined. Temperature ranges are shown in nineteen colors approximating the characteristic hot-body radiant hues. At the right of the chart twenty-three fundamental metallurgical terms are defined and explained. A diagram symbolizing the change in grain size with temperature is shown at the left. This chart measures 16¼ by 21 inches and is available without charge to industrial executives.



For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.



14—Dry Type Transformers

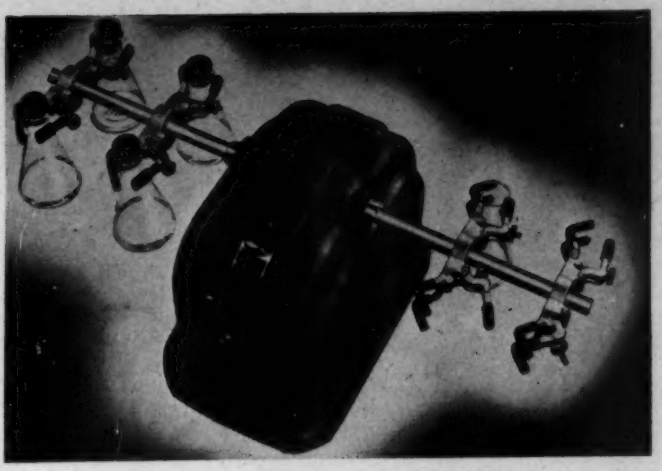
Dry type Class B insulated load center transformers for plant power distribution circuits are being built by Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14, in the following ratings: Three-phase, 60-cycle, 100 to 2000 kva, with high voltages of 2400, 4160, 4800, 7200, 12,000, 13,200 or 14,400, and low voltages of 600, 480, 240 or 208Y/120. All are rated 80° C. rise, with natural ventilation. Transformers are housed in paneled enclosures designed for indoor installation. Removable panels facilitate cleaning and inspection. Vertical ducts through the core and vertical and horizontal ducts through the winding provide maximum ventilation. Insulation materials are mainly class B with class C materials used where extra strength is needed. Ask for Bulletin TU-56.

15—Thermistors

Introduction of "Thermistors," electrical semi-conductors that respond to temperature variations as small as one thousandth of a degree centigrate, is announced by General Electric Chemical Department, Pittsfield, Mass. The devices are made from mixtures of semi-conducting metallic oxides and possess a high negative temperature coefficient. Available in the form of rods, disks, and beads, G-E Thermistors are especially adaptable as the sensitive element in thermometers, time delay relays, switching devices, and other types of indicators and controls. They can be used with either a-c or d-c current and may be actuated etiher by ambient temperatures or by internal heating of the element. Moreover, by means of systems employing G-E Thermistors, temperature variations may be transmitted automatically to distant locations.

16—Shaker

The Burrell Technical Supply Co., 1942 Fifth Ave., Pittsburgh 19, Pa., announces a new "Wrist-Action" shaker with specially designed finger-grip clamp which makes it possible to shake any size volumetric flask, standard round bottles up to four ounces, standard square bottles up to four ounces, erlenmeyer flasks up to 2000 ml, as well as Squibb separatory funnels up to 1000 ml, short neck, flat or round bottom flasks up to 2000 ml, and test tubes up to 50mm. diameter. The Burrell shaker simulates hand shaking.



Burrell Wrist Action Shaker with Finger Grip Clamp in All its Varied Positions

J-M Interlocked No. 270 SEALS HOT OIL with less gland pressure

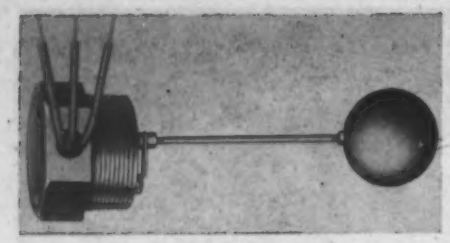
Less gland pressure means more life for packing! That's one of the reasons why J-M No. 270 Interlocked lasts longer in hot oil service.

J-M Interlocked requires less compression because it is braided square for greater contact on the rod or plunger . . . not braided round and pressed square like ordinary packings.

Another reason J-M Interlocked lasts longer is its dense, integral structure without jackets or plaits to come loose. Every strand of its long fibre asbestos extends into the packing and is securely *interlocked.*

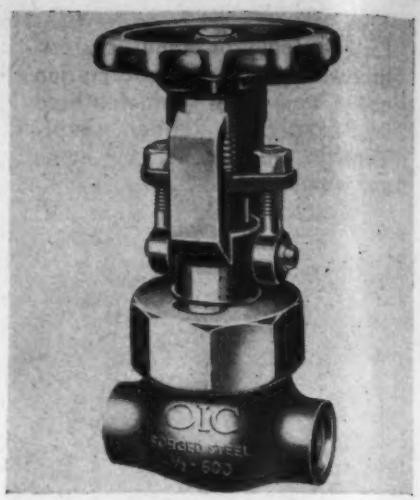
J-M Interlocked is but one of the many special J-M Packings for oil service at your Supply House. Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville PACKINGS & GASKETS



17—Liquid Level Control

Development of a new float and switch unit for liquid level control service is announced by Magneswitch, Inc., 4267 South Western Boulevard, Chicago 9. Designed for industrial service, the units are distinguished by simplicity and absence of conventional packing boxes, bellows, or diaphragms. The key component is best described as a magnetic proximity switch containing an Alnico permanent magnet element. The switch has no direct mechanical linkage with the float. Instead, it is separated by a non-magnetic, stainless steel plate which, in closed tank installations, serves as a pressure barrier or seal between the internal and external parts of the assembly. Standard units include models designed for mounting directly in the side or end of open or closed vessels with internal pressures up to 600 psi, and temperatures to 700° F. All exposed parts are of corrosion resistant materials. Dimensions, specifications, and wiring diagrams, together with information on switch ratings, is contained in a new bulletin.



18—Forged Steel Valves

The Ohio Injector Company, Wadsworth, Ohio, announces an entire line of 600-pound forged steel valves. This line of forged steel valves is available in gates, globes, angles, and checks, with various types of trim. They are producing screwed, flanged, and socket-weld types. Each OIC valve bears an identification plate describing type of trim, pressure-temperature range and catalog number.

19—Midget Puller

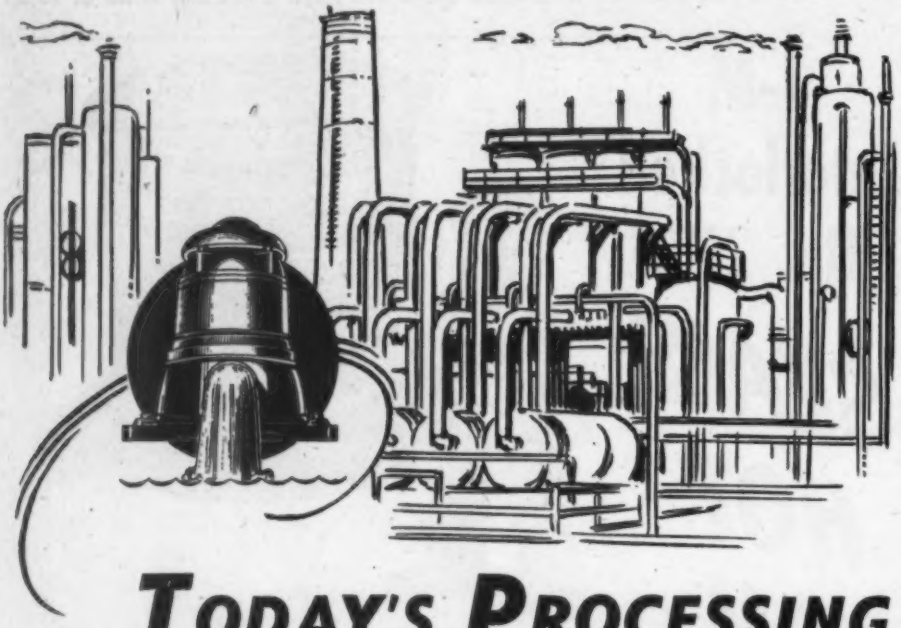
The Coffing Hoist Company, Danville, Ill., has recently introduced a new "Mighty Midget" puller designed to pull or lift 500 pounds. The tool has rated capacity of 500 pounds but its chain has a tensile yield of 2000 pounds and its snap hooks a tensile yield of 3000 pounds. It has a "safety load" handle designed to bend at about 800 pounds, a level well below the yielding point of any other part of the puller. Weighing only 6½ pounds (with chain), this midget puller features a two-way handle that can be used as a high speed crank or a ratchet lever. The chain coiled up it fits into a small tool box. The puller requires only 28 pounds of effort to result in a 500-pound pull, Bulletin MP-1 says.

20—Rubber-Lined Hose

A new type of rubber-lined hose, "light in weight but extremely strong and flexible," is offered by Quaker Rubber Corporation, Philadelphia 24. "Quaflex" hose is said to fold flatly, is quickly and easily dried and is leak-proof. It is available in 25, 50, 75 and 100-foot lengths with diameters of 1½, 2 and 2½ inches.

21—Condenser Tube

Revere Copper and Brass Incorporated, 230 Park Avenue, New York 17, has announced a new condenser tube—to be known as Cupro-nickel, 10 percent alloy No. 508—which is 88.5 percent copper, 10 percent nickel, and 1.5 per-



TODAY'S PROCESSING
DEMANDS LOW COST WATER SUPPLY

Refiners faced with many added processing operations are in need of more—and lower cost water. Old, low efficiency systems are eating heavily into profits and production is often being retarded. The way to change the situation is to install a Layne well water system and thus obtain larger quantities of water at lower cost. Layne well water systems are world famous for high efficiency, low operation cost, dependable service and long life. Once installed according to Layne standards, there is little or no upkeep cost. For literature, address Layne & Bowler, Inc., General Offices Memphis 8, Tenn.

√

Layne well water systems are designed and built in capacities from several thousand up to many million gallons daily. Installation may be of the all weather type requiring no housing. Controls are completely automatic. Flow may be direct into the mains or to elevated tanks.

LAYNE

WELL WATER SYSTEMS

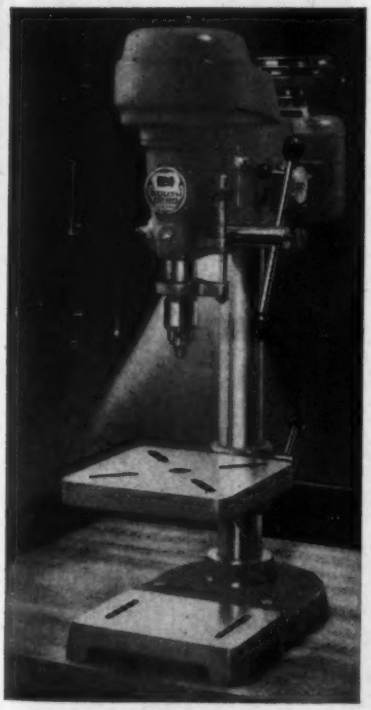
When writing the manufacturer of new equipment for literature or more information identify his product by name and number listed in Petroleum Refiner.

cent iron. Preliminary tests indicate this new alloy will perform favorably in comparison with cupro-nickel, 30 percent. The new condenser tube is recommended for installations, encountering high velocities, high temperatures, brackish or salt water, and bad pollution.

22—Precision Drill Press

A new 14-inch precision drill press has been announced by South Bend Lathe Works, 351 East Madison Avenue, South Bend 22, Ind. The manufacture of a drill press is a departure for this company, which has manufactured precision lathes exclusively for over 40 years. Most specifications are common to both bench and floor models, now in production, each having a capacity to drill ½-inch in iron or steel at the center of a 14-inch circle. This drill press features a built-in light with independent switch which provides shielded illumination for the work area and a quick acting belt tension release lever which simplifies changing the spindle speeds and returns the vertical mounted motor to its original position after each change. The spindle has a maximum travel of four inches, with spindle speeds of 707, 1305, 2345 and 4322 rpm.

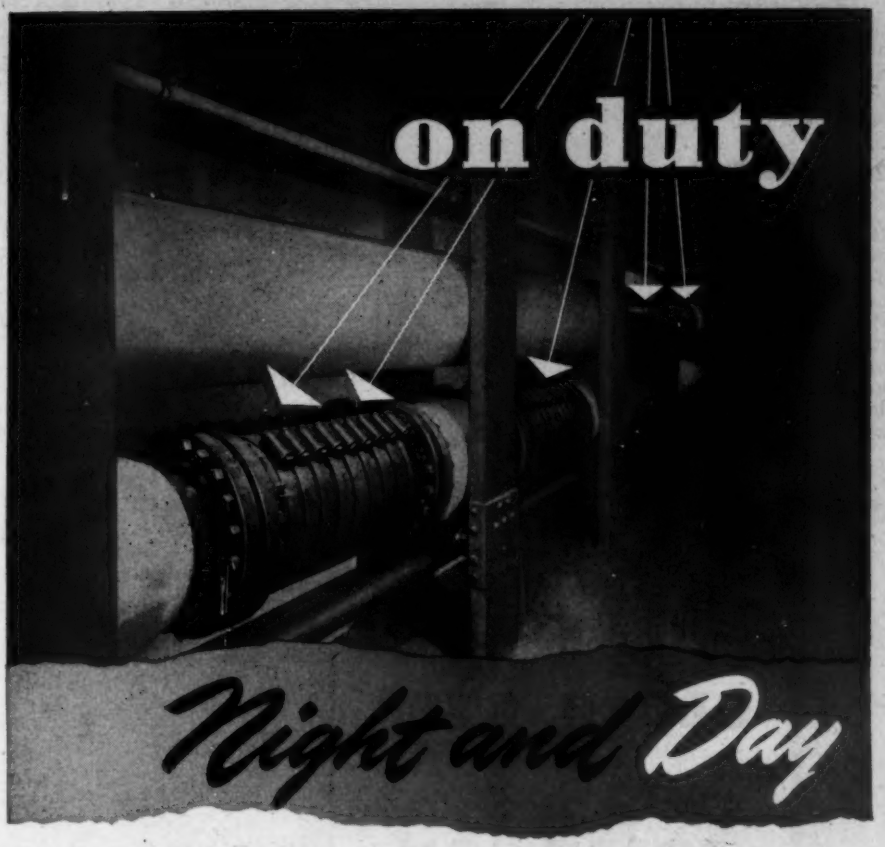
South Bend also is to start production shortly of a new 7-inch precision bench shaper.



Drill Press

23—Metallizing Gun

Only ten cubic feet of air per minute for metallizing is said to be required for the new "Light-Duty—Low Air" L Gun announced by Metallizing Engineering Co., Inc., 38-14 30th Street, Long Island City 1, N. Y. This gun also has "new



★ Here are two of the many Zallea Expansion Joints installed in high pressure steam lines from Capitol Power House to U. S. Government Printing Office, Washington, D. C.

These expansion joints are always "on duty" to assure uninterrupted production—and a continuous flow of steam to the Printing Office. Efficiently and tirelessly, they perform their job of absorbing movement due to contraction and expansion of the steam lines.

It's the high quality built into every Zallea joint that makes them long lasting—even under the severest service. Remember, there is *no* packing to deteriorate—*no* maintenance required.

Zallea Corrugated Expansion Joints are made in non-equalizing, self-equalizing and duo-equalizing types, depending upon operating conditions . . . of copper, stainless steels and other corrosion resistant alloys . . . for a wide range of temperatures and pressures in many sizes. Write today for the brand new Zallea Catalog 47. *ZALLEA BROTHERS, 890 Locust Street, Wilmington 99, Del.*

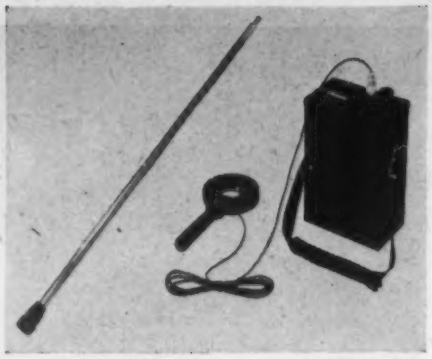
Zallea
EXPANSION JOINTS

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

turbine construction requiring only one-third the power, making a large compressor unnecessary and new nozzle construction which minimizes consumption of acetylene oxygen. Ask for Bulletin 55.

24—Wire Cloth

Michigan Wire Cloth Company, 2100 Howard street, Detroit 16, is now in production on its new "Michigan Specification 4200," developed to replace 200-mesh wire cloth, which has been in short supply since 1941. The manufacturers state that Specification 4200 is equal to 200-mesh in filtering and straining action, yet it is seven times as strong. It is available in Monel metal and brass, and in other metals to special order.

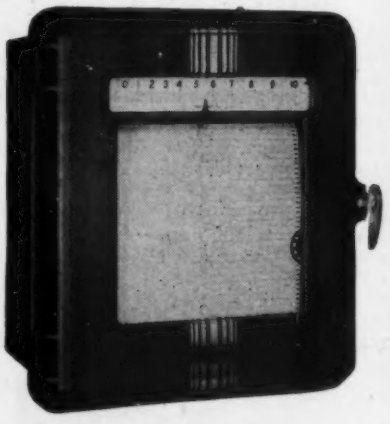


25—Circuit Tracer

Eltron circuit tracer model 104C, manufactured by Eltron Inc., 407 N. Jackson St., Jackson, Mich., provides a simple means for tracing concealed wiring, locating buried pipes or cables, and locating short circuits or grounds in electrical wiring. In operation a 60-cycle current from normal electric power service sources is impressed on the circuit to be traced through a capacitor. Eltron circuit tracer and pick-up loop are sharply tuned to respond to the 300-cycle signal developed by the capacitor and will permit tracing the path of the desired circuit even with other nearby power circuits in normal operation.

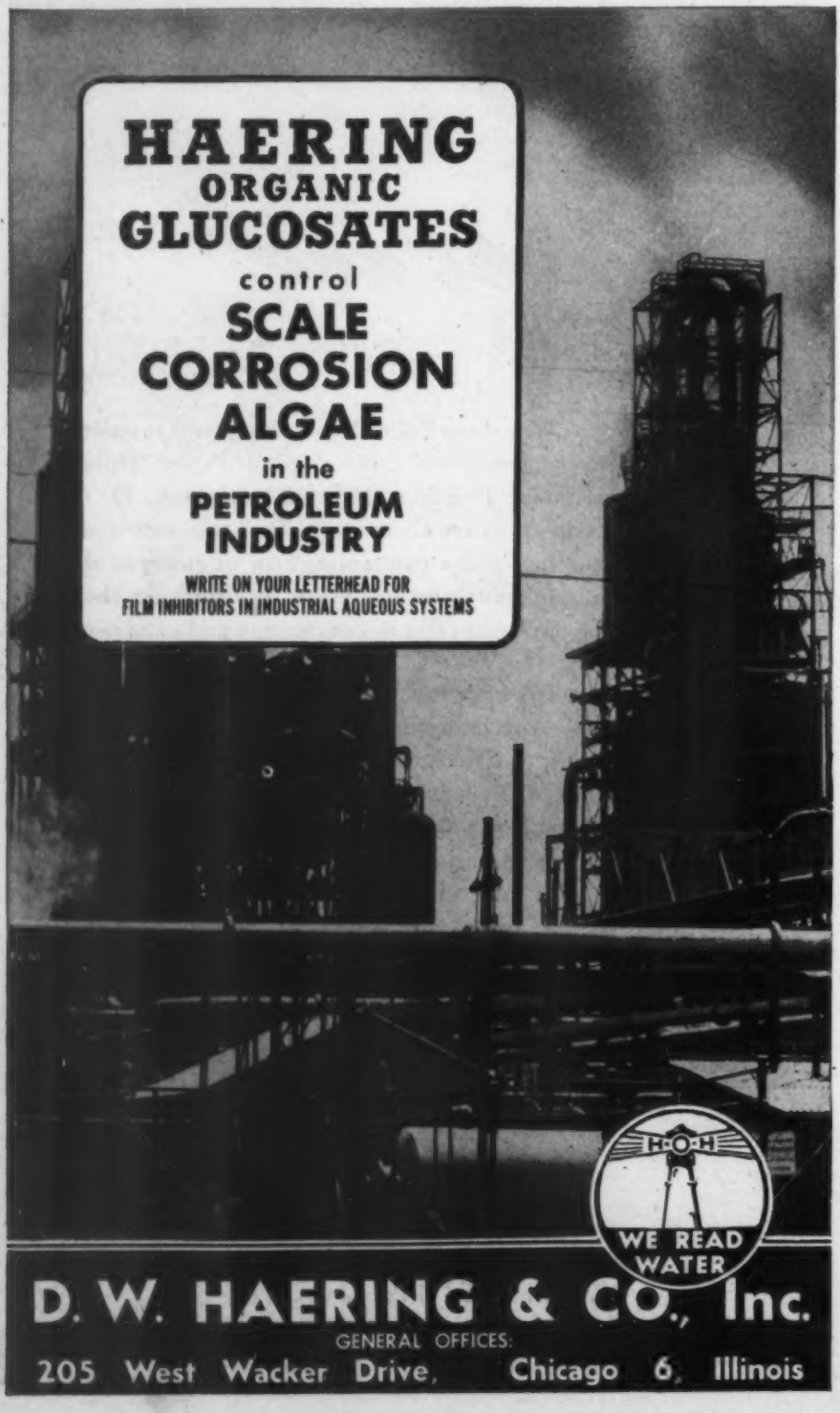
26—Oxygen Recorder

As a means of checking on combustion efficiency in furnaces and boilers, "Micromax" oxygen recording equipment, developed by Leeds & Northrup, 4934 Stenton Avenue, Philadelphia 44, will handle many applications beyond the scope of CO_2 Recorders. In particular, this equipment is used as a guide to regulating excess air in furnaces such as glass tanks, cement kilns and open-hearth steel furnaces, where carbon dioxide is evolved by process reactions. It is also successful as a means of checking combustion in boiler furnaces which fire several different fuels simultaneously or in succession. Micromax oxygen recorders operate on the thermal conductivity principle, used for years in Micromax instruments for CO_2, SO_2, H_2 and other gases. All parts which contact gas are made of glass, so the equipment is corrosion-proof and stable in calibration. Two models are available: for extra visibility of scale, a round-chart; for a highly detailed record, a strip-chart model.



27—All-Purpose Tool Kit

A new all-purpose tool kit, announced by Ingersoll-Rand Company, 11 Broadway, New York 4, is compact and portable and includes the new electric impact tool—with standard accessories for drilling steel, masonry or wood, reaming, wire brushing, nut-running and nut-removal, tapping, driving and removing screws, extracting broken cap screws and studs, and hole saw work. The kit is assembled complete or with accessories as required. With standard equipment, the kit contains the impact tool with a Jacobs collet type chuck, six hex sockets of varying sizes, a Morse taper socket, and adapter sleeve. The impact tool is said to be the only Universal motor driven, all-purpose tool employing the impact mechanism. It plugs into any AC-DC electric socket and runs as



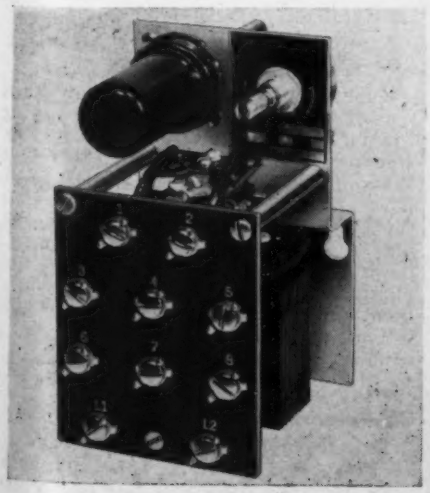
All-Purpose Tool Kit

any conventional electric tool till the going gets tough. Then the impact mechanism automatically functions and delivers 1900 rotary impacts per minute to the job.

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

28—Electronic Relay Control

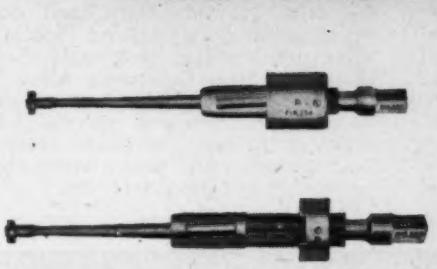
R-S Products Corporation, Philadelphia, announces the new "Leveltronic" relay, a new control for applications including liquid level and interface control and alarm, pressure and flow control and alarm, temperature control and alarm, high foam control and alarm. The circuit is of the positive acting thyratron type with the tube current limited to less than 1/3 its maximum value. Two models cover a range of 20 ohms to above 2 megohms with continuously variable sensitivity giving 2-to-1 discrimination over the full range. The circuit is stable over a wide range of voltage fluctuations. Ask for Catalog 27.

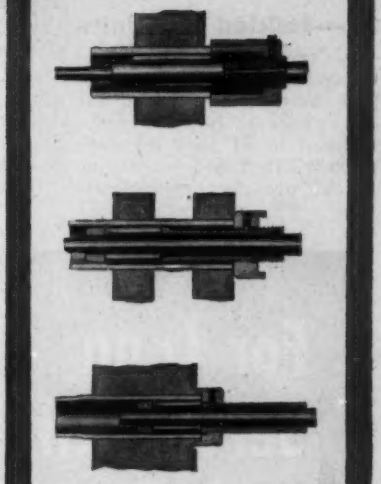


Electronic Relay

Wiedeke

TUBE EXPANDERS FOR DEPENDABLE . . . ECONOMICAL SERVICE





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Designed especially for rolling small tubes in Condensers, Heat Exchangers and similar units.
Style No. 254 is adaptable for rolling tubes to a depth of 2"
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Leading users everywhere know there is a Wiedeke Tube Expander for every application.
For complete details, see your local dealer or write us today

The Gustav Wiedeke Company
DAYTON 1, OHIO

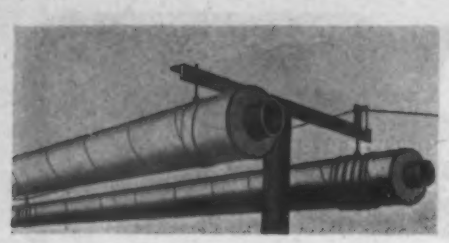
FILTER UNITS by MULTI-METAL

This large sump strainer basket, of heavy copper mesh trimmed with heavy angle iron rings, is another example of Multi-Metal's all-round ability to design and fabricate complete wire and filter cloth units. It is only one of hundreds of Multi-Metal fabricated units setting outstanding performance records throughout the processing industries. This is to be expected of Multi-Metal's 35 years of production and application of wire and filter cloth units for improving processing efficiency and reducing maintenance costs.

Multi-Metal has available a large variety of filter and wire cloth of all meshes, weaves and metals — by the yard, piece or roll. Write today for wire cloth samples and useful Multi-Metal catalog on wire cloth. Send along your prints and specs for prompt quotations.

More than 35 *years of service to process industries*

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.



29—Foilclad Pipe Units

A recent development of Ric-wiL Company, Cleveland, Ohio "Foilclad" pipe units for overhead distribution of oil, process liquids and steam, are shipped in 21 foot sections, completely prefabricated and ready for installation. In the prefabrication of these units asbestos, cork or other insulation, as specified, is machine coated with high-temperature asphalt and tension wrapped with asphalt-saturated asbestos felt. A second coating of asphalt is followed by a tension wrapping of alumnium or copper foil.

30—Stainless Tubing

Detailed engineering information on the selection, fabrication and use of Stainless Steel Tubing and Pipe is provided by a data book published by Carpenter Steel Company, Alloy Tube Division, Union, N. J. Chapter subjects include selection and specification of stainless tubing, corrosion resistance, heat resistance and heat transfer characteristics, fabrication data, etc.

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CORNING GAUGE GLASSES, SIGHT GLASSES, OIL CUP AND LUBRICATOR GLASSES More Than Meet Requirements
For trouble-free service, always specify Corning products when you need gauge glasses, sight glasses, oil cup and lubricator glasses. Made to exacting standards and tested for pressure and temperature shock, you can be sure that the product you select will stand up.
Gauge Glasses: PYREX and CORNING brand tubular gauge glasses and Macbeth brand flat gauge glasses provide good visibility over prolonged periods, and even under severe conditions.
Sight Glasses: PYREX brand sight glasses are made especially for ovens, absorption columns, reaction kettles, furnaces, pressure vessels, stills and tanks of any kind where safe, internal visibility is necessary.
Oil Cup and Lubricator Glasses: PYREX and CORNING brand products give you visibility plus long life.
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SALES OFFICES: NEW YORK, CHICAGO, SAN FRANCISCO
PYREX GAUGE GLASSES
BRAND

31—Steam Jet Ejectors

Catalog 1462, "Steam Jet Ejectors, has been issued by C. H. Wheeler Manufacturing Company, Lehigh and Sedgley Avenues, Philadelphia 32. Included are flow diagrams, engineering data, installation guide, formulae, curves and tables covering the theory and operating characteristics of steam jet ejectors for all classes of vacuum service.

32—Prime Pumps

The complete new line of Rex "Easy Flow" speed prime pumps is described in Bulletin 47-12, just published by Chain Belt Company, 1600 W. Bruce St., Milwaukee 4, Wis. The various design advancements are listed and pictured by cutaway and "exploded" photos. Included are helpful application information and tables.

33—Neoprene

The Rubber Chemicals Division of E. I. du Pont de Nemours & Company, Wilmington 98, Del., has issued The Neoprene Notebook containing information on laboratory results and industrial applications for neoprene products. The notebook is published approximately four times a year.

34—Finned Tubes

Bulletin 1626 on finned-tube heat transfer apparatus published by The Griscom-Russell Company, 285 Madison Ave., New York 17, describes purposes of fin-type elements and services to which they are adapted. The applications of elements with helical K-Fins and with longitudinal G-Fins are fully explained, as are the various designs of condensers, heaters, coolers and heat exchangers furnished with each of these finned elements.

35—Oil Burning System

Peabody Engineering Corporation, 580 Fifth Avenue, New York 19, has reprinted their "Constant Differential Oil Burning System" and general distribution has been arranged. Completely diagrammed and charted, this bulletin No. 109-A not only explains how the constant differential system operates but also illustrates, in cut-away fashion, the atomizer itself with explanation of how extreme fluctuating loads are handled under positive regulation with full flame control.

36—Absorption Plants

Technical Bulletin 2225, "Blaw-Knox Gasoline Absorption and Stripping Plants," published by Blaw-Knox Construction Company (Chemical Plants Division, Gas Equipment Department), Box 778, Pittsburgh 30, Pa., describes the company's portable and automatic unit to control the hydrocarbon dewpoint of natural gas. Operation of the plant, typical installations, key equipment and the flow cycle are included as is a technical section reviewing design calculations.

37—Iron Casting

Bulletin 1115, offered by McNally Pittsburg Foundries, Inc., Pittsburg, Kas., includes analytical data on process cast iron and a specification summary on iron castings.

38—Stainless Steel

Alloy Metal Wire Company, Prospect Park, Moore Station, Pa., announce availability of the Almet Stainless Steel Handbook which contains data for comparing qualities, characteristics, uses, mechanical, physical, electrical, magnetic, heating resisting and corrosion-resisting properties of stainless steels. Graphs, charts, tables and comparative form on the proper application of the different stainless steels are presented. Almet claims the book establishes "a sound foundation of what stainless steels are, how to fabricate them and what you can expect of them under different conditions."

39—Fittings and Flanges

The Tube-Turn Catalog and Engineering Data Book No. 111, on the subject of welding fittings and flanges for industrial piping, now has a 20-page supplement devoted to specifications that cover new items in Tube-Turn's line of fittings. It is 6 x 9 inches in size. Write Tube Turns, Inc., 224 East Broadway, Louisville 1, Ky.

40—Tube Cleaners

The complete new line of Rotojet tube cleaners manufactured by the Elliott Company, Roto Division, Sussex Ave., Newark, N. J., is described and illustrated in a new bulletin. Also shown are various types and sizes of Rotojet motors for operation with water, compressed air, and steam. Parts and accessories illustrated, include various types of heads, air valves for one-man operation, lubricators, and hose. Tables list sizes and types of tubes.

41—Tube Cleaners

A new catalog (No. 76) of tube cleaners, announced by Thomas C. Wilson, Inc. 21-11 44th Avenue, Long Island City 1, N. Y., covers the complete Wilson line with virtually every type of cutter-head described in detail. Brushes and air, steam, and water-driven motors also are included. One section shows a variety of "custom-made cleaners. All listings are organized for easy reference. Application data as well as technical information, operating hints, and other pertinent data are included.

42—Rotameter

Folder No. 20 issued by Brooks Rotameter Company, Box B 6248, describes its special "full-view rotameter with safety shielding for corrosive services." External as well as internal metal parts are made of stainless steel, these including side plates, window frames, gland followers, cap screws and gland bolts. The rotameter is made with screwed connections in sizes ¼ inch to 1½ inches and with flanged connections in sizes 1 to 3 inches. It will measure flow rates as high as 120 gpm of liquid or 240 cfm of gas.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

For the fellow who hollers "HELP" at cleaning time!

AIRETOOL'S NEW GEARED CLEANER
FOR CONDENSER AND HEAT EXCHANGER TUBES

★ **CONSTRUCTION . . .**

sturdy aluminum-alloy case—all moving parts heat-treated alloy steel. Slip-fit construction. Weight — 35 pounds.

★ **OPERATION . . .**

powerful motor—air or steam driven. Convenient handle valve for positive control. Built-in flushing system. Noise reducing muffler.

★ **PERFORMANCE . . .**

ALWAYS SATISFACTORY, even when tubes are completely closed with scale.

NO. CC-375 GEARED CLEANER

Thoroughly cleans all types of straight tubes ⅜" to 1¾" I.D. whether lightly scaled or completely closed.

For additional information on geared and direct drive cleaners for condensers and heat exchangers, write to the Airetool Manufacturing Co., 316 S. Center St., Springfield, Ohio, for Bulletin No. 40.

THERE'S AN AIRETOOL TUBE CLEANER AND EXPANDER FOR EVERY TYPE OF TUBULAR CONSTRUCTION!

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

N. Y. Office: 50 Church St., New York 7, N. Y.

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USERS everywhere are testifying to the outstanding service performed by this general purpose semi-metallic packing. DURA PLASTIC provides improved sealing for gasoline—water—air—steam—oils and chemicals . . .

★ No "breaking" when formed around shafts

★ Remains uniform in shape under compression.

★ Retains resiliency throughout life of its use

★ Lubricated metallic shreds reduce frictional wear

WRITE TODAY FOR YOUR COPY OF FILE NO. DPPR . . . describing types and styles of metallic and semi-metallic packings to meet your specific needs.

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The PERFECT SEAL

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The most complete line of Stainless Steel Welding Fittings

P. P. & E. STAINLESS STEEL WELDING FITTINGS . . .

Every P. P. & E. stainless steel welding fitting is permanently identified with Stainless Type number and "stock lot" number. Years after a fitting has been produced, we can quickly refer to the exact analysis of the steel used, and to all other pertinent data. Thus, you are assured that fittings purchased over a period of time will be uniform—in analysis of stainless steel, and in every other specification.

This carefully-recorded "pedigree" is indispensable when you enlarge, remodel, or re-adapt your stainless piping system.

CATALOG S-309 lists 2824 stock items to match pipe and tubing of various wall thicknesses in sizes from ⅛" through 12". In Stainless Types 308, 316, 347.

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About EQUIPMENT SERVICE SUPPLIERS

Cooper-Bessemer to Expend $600,000 for New Equipment

The Copper-Bessemer Corporation, Mount Vernon, Ohio, has embarked on a $600,000 improvement program, "in an effort to increase its production of equipment sorely needed to help alleviate the shortage of natural gas."

Called for are the purchase of $325,000 worth of new machine tools for its Grove City, Pa., plant and the expansion of its foundry facilities, and about $275,000 for equipment for the Mount Vernon plant. Company officials estimate that production will be increased by from 25 to 30 percent as a result of these expenditures.

Minneapolis-Honeywell Opens New Branch in Wichita, Kan.

A branch office serving Wichita, Kans., and surrounding territory has been opened by Minneapolis-Honeywell Regulator Company at 1514 East Central, with Lynn H. Johnson, Jr., in charge.

Johnson served in the production and sales departments from 1933 until 1942 when he joined the U. S. Army where he rose to rank of captain in the ordnance department. After rejoining Honeywell he was transferred in January, 1947, to Minneapolis headquarters as sales manager of the gas controls division.

Other personnel of the new office include Donald D. Baker, sales engineer for the industrial instrument division and Robert F. Perkins, sales engineer for the heating controls division.

Edwin D. Lowthian Joins Mixing Equipment Company

Edwin D. Lowthian has joined Mixing Equipment Company, Inc., Rochester, N. Y., as senior process engineer to augment the company's field engineering service.

Lowthian for five years was associated with the Chemical Warfare Service, and before the war was employed by the E. I. du Pont de Nemours Company's engineering division. A graduate of Johns Hopkins University in chemical engineering, Lowthian more recently was with the American Cyanamid Company's process engineering section.

Lukens Steel Announces Two Official Promotions

Charles Lukens Huston, Jr., has been elected vice president and Robert G. Bloom controller of Lukens Steel Company, Coatesville, Pa. Huston, who will continue as executive assistant to the president has been associated with Lukens and its divisions since 1939. Previously, he was with American Rolling Mill Company for 10 years, following his 1928 graduation from Princeton University. In 1943, Huston was named president of Lukenweld, a division of Lukens. In 1944, he assumed the general managership of the division as well as continuing as president. In 1946, he was named executive assistant to the president of Lukens.

Huston

Bloom has served as controller of Lukens Steel Company since 1943. Starting with the company in 1927, he was, successively, chief clerk, assistant controller and auditor.

Hagan Opens in Denver

Hagan Corporation, Pittsburgh combustion and chemical engineering firm, opened a branch office at 2018 Blake Street, Denver 2, February 1. W. C. Bennett, named manager there, is a veteran of 15 years with Hagan and was in charge of engineering service in the St. Louis area from 1941 to 1947. Last

Hi-Pressure Gage Glasses

Round, Tubular and Flat Type

RUBBER GAGE GLASS GASKETS

Series 750 . . . All Sizes

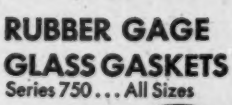

Fig. 21 Fig. 22

Inclined for Better Visibility

Standard Type—Offset Adjustable Inclined Gage Fittings

Fig. 44

Fig. 12

Other Ernst Specialties are given in Catalog No. 48-P

GAGE GLASS ILLUMINATORS
NEW PLASTIC GUARDS
SIGHT FLOW INDICATORS
SPLIT-GLAND WAFER GAGE
STEEL GAGE VALVES
FLAT GLASS INSERTS
ALL IRON GAGES
HIGH & LOW ALARM COLUMNS
MICA SHIELDS AND GASKETS
AND OTHER HELPFUL TIPS ON BOILER ROOM SAFETY

Fig. 13

Leakless Super Try Cocks, Bronze and Forged Steel Construction

Send for Catalog 48P

Ernst WATER COLUMN & GAGE CO.

LIVINGSTON, N. J. LIVINGSTON 6-1400

THIS COUPLING-VALVE IS

Trip-proof refers to the integrated valve lever and locking collar designed to prevent the coupling being disconnected while the valve is open. The valve must be closed before the locking collar may be rotated. IMPORTANT RESULT: *No inadvertent spilling of highly volatile and inflammable fluids and gases.*

THE ROYLYN 2800 2½" TRIP-PROOF COUPLING-VALVE IS THE

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AVAILABLE TODAY FOR THE LOADING AND TRANSFERRING OF FUEL

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You can get the kind of gages YOU WANT when you take your gage problems to Jerguson.

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Standard gages and valves, of course, are available at Jerguson's in the most complete and varied line offered anywhere.

Corrosion troubles can be eliminated with Jerguson Valves of special materials to withstand liquid action.

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November he was named district engineer in an area comprising Colorado, West Texas, New Mexico and Wyoming.

Also effective February 1, Maintenance Engineering Corporation, which represents Hagan in a large area of the Southwest and in Mexico, extended its sales and service coverage to include additional territory in West Texas and southern New Mexico.

Allegheny Ludlum Changes

Allegheny Ludlum Steel Corporation has announced appointments in its production, research, engineering and sales staffs as follows:

R. J. Bryan as plant manager of the Buffalo foundry; Dr. P. K. Koh, as associate director of research in charge of tool and die steel and allied products; George I. Bottcher as assistant chief engineer and C. M. Binney as assistant district manager of the New York sales district.

Bryan succeeds D. M. Scott as plant manager. L. V. Klaybor, Dunkirk plant, has ben appointed assistant to Dr. Koh.

Merle J. Graham has been named manager of the West Leechburg, Pa., plant and Frank G. Benford assistant plant manager. Graham has been acting plant manager since early in 1947.

Zallea Firm Name Changed

Zallea Brothers and Johnson has announced that it has changed its firm name to Zallea Brothers. The address is still the same: Taylor and Locust Streets, Wilmington 99, Delaware. No change has been made in the line of Zallea expansion joints and flexible connectors, the announcement said.

Hunt Company Named

Minnesota Mining & Manufacturing Co., St. Paul, Minn announce the appointment of A. J. Hunt Company of Odessa, Texas as distributors of their new anti-corrosion protective coating, "Coro-Gard."

Oil Well Supply Names Redman Division Engineer

Appointment of William J. Redman as division chief engineer of the Wilson-Snyder Manufacturing Division of Oil Well Supply Company, Braddock, Pa., has been announced by this U. S. Steel subsidiary.

Redman

Redman attended the University of Pittsburgh and Carnegie Institute of Technology, starting with Oil Well Supply at the Wilson-Snyder plant in 1923 as a draftsman. He was appointed assistant chief engineer in 1942, holding that position until his present appointment.

Redman, who is a member of the American Society of Mechanical Engineers, resides in Pittsburgh.

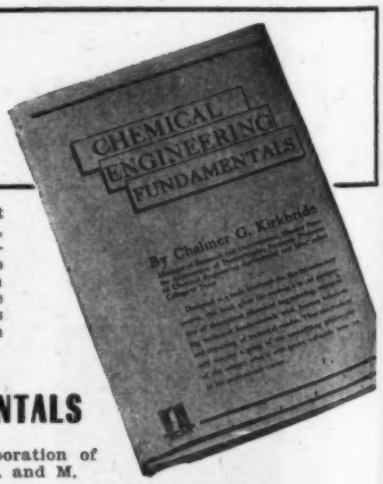
Metal Goods Corporation to Handle Tri-Clover Products

Tri-Clover Machine Company, Kenosha, Wisc., has appointed Metal Goods Corporation, 5239 Brown, St. Louis, as distributors for its complete line of corrosion-resistant products. This includes fabricated stainless steel conical end, welding and recessed-end fittings for industrial liquid conveying line use, as well as centrifugal pumps for industrial use.

Sand-Banum Named Distributor

Western-Sand-Banum Company, 703 M & M Building, Houston, has been appointed distributors for Masters anti-acid lubricants and Masters metallic compound. The Masters products are made by James K. Harbinson & Company, Buffalo, N. Y.

How to maintain better control over unit operations . . . chemical processes . . .



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CHEMICAL ENGINEERING FUNDAMENTALS

By CHALMER G. KIRKBRIDE

Manager, Houdry Laboratories, Houdry Process Corporation of Pennsylvania; Formerly, Distinguished Professor, A. and M. College of Texas

Whatever your problem—whether you're checking caustic soda manufacture . . . thermal cracking of petroleum . . . or alkylation—you can be sure your basic calculations and procedure are sound with help you get in this authoritative manual. The author, an experienced chemical engineer, knows your requirements—gives you the kind of dependable guidance you need in handling all types of chemical engineering problems.

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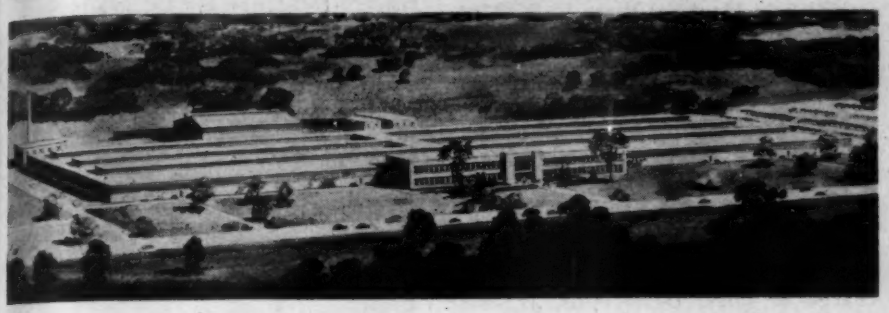
Chicago Pneumatic Announces New Plant



Chicago Pneumatic Tool Company will construct a new plant in Utica, New York, this spring. The plant, one of the most modern industrial buildings in the East according to officials, will have more than a half-million feet in floor space, all on one story. Newest techniques in materials handling, work simplification and safety provisions will be utilized.

Official, Plant and Sales Changes Made by Pennsalt

William F. Mitchell, superintendent of the Wyandotte, Mich., plant, has been named assistant vice president of Pennsylvania Salt Manufacturing Company and Gustave A. Nelson, formerly assistant superintendent at Wyandotte has succeeded him there. Announcement also was made of the appointments of Herman J. Eichengofer and Hugh C. Land as assistant superintendents of the Wyandotte plant.

Another Pennsalt change involves Hugh R. Bishop who has been named sales representative in the Chicago territory for the heavy chemicals division succeeding C. Harvey Anderson, recently transferred to the Wisconsin-Minnesota territory.

Butler & Land to Represent The Louis Allis Company

The Louis Allis Company, Milwaukee 7, has announced appointment of H. L. Land and J. J. Butler as new representatives in Dallas. Each man has had some 19 years experience in sales engineering on electrical equipment, most of it in this area, Louis Allis, Jr., said. Butler & Land, whose address is 3405 Milton Avenue, Dallas 5, will handle equipment sales in East, North, Central and West Texas including the Panhandle.

Airco Pacific Vice Presidents

Air Reduction Pacific Company, new subsidiary of Air Reduction Company, Inc., recently organized to take over the West Coast business of Air Reduction

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Sales Company, has named four vice presidents with district offices as follows:

L. A. Hamilton, Seattle, with offices at 3623 East Marginal Way; E. W. MacCorkle, Jr., Portland, with offices at 430 N.W. 10th Avenue; H. W. Saunders, San Francisco, with offices at 1845 Park Avenue; and H. A. Hoth, Los Angeles, with offices at 2423 E. 58th Street.

New Officials Are Named By The Louis Allis Company

The Louis Allis Company, Milwaukee, Wis., last month created three new offices filled as follows: Vice president in charge of sales, Louis Allis, Jr.; vice president in charge of manufacturing, Frank O. Kovich; and vice president in charge of engineering, T. R. Wieseman.

C. G. Skidmore has been named sales manager, James H. Daganhardt, chief engineer and John J. Kirkish, chief of electrical design.

The company is moving into a large factory building and office recently completed and E. P. Allis, president, has stated that with new facilities now being erected he expected a substantial reduction in over-all costs through increased efficiency.

Mason-Neilan Sends Head To Open New Atlanta Office

Mason-Neilan Regulator Company has appointed E. Putnam Head manager of its Atlanta office, 101 Marietta Street.

Head

Head joined Mason-Neilan Regulator Company's factory staff in 1936. He was appointed to the sales engineering staff in the New York office in 1937 where he remained until 1939 when he returned to Boston, joining the factory staff as production supervisor during the war years. He was then appointed manager of the Buffalo office.

Head assumed his new duties in Atlanta on January 1.

Allis-Chalmers Announces Promotion of Two Officials

E. H. Horstman and Hans P. Dahlstrand have been named respectively chief engineer and director of engineering of the Allis-Chalmers steam turbine department.

Horstman, formerly assistant chief engineer of the Allis-Chalmers steam turbine department, assumes complete charge of steam turbine engineering. He has been with the company since 1923. Dahlstrand, associated with Allis-Chalmers since 1904, holds many patents and has contributed outstanding improvements in steam turbine design.

Brown Instrument Company Opens Office in Memphis

Brown Instrument Company has opened a new district office at 922 Dermon Building, Third and Court streets, Memphis, Tenn. Since the first of the year other offices have been established at Denver and Salt Lake City.

Holdom Named Eastern Representative of Girdler

K. G. Holdom has been appointed Eastern representative for the gas processes division of The Girdler Corporation, Louisville, Ky.

Holdom

Holdom, soon after graduating from Massachusetts Institute of Technology, joined the M. W. Kellogg Company where he worked in the process division and also aided in the development of the fluid catalytic cracking and hydroforming processes. During the war he was employed by Cities Service Refining Corporation at Lake Charles, La., and later joined Houdry Process Corporation as a project analysis engineer in the sales department.

Holdom will be station at 150 Broadway, New York.

Airco Lists Promotions

Dale D. Spoor has been appointed sales promotion manager of Air Reduction Sales Company, Russell S. Schmidt succeeding Spoor as dealer sales manager. As sales promotion manager Spoor's duties will include the supervision of a sales training program, and, the establishment of sales promotion programs for the various Airco sales districts throughout the country.

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Frank Mason Promoted By U. S. Electrical Motors

Frank M. Mason has been named vice president in charge of the Atlantic plant of U. S. Electrical Motors, Inc., with headquarters at Milford, Conn.

Mason

Mason started in the test department in 1930 and successively was in charge of the test department, service department; then assistant chief engineer, Chicago district manager, and manager of the Brooklyn assembly plant. When the Atlantic plant was built, the Brooklyn assembly plant was moved to Milford and Mason then became manager of the Atlantic plant. He has been in charge there since 1943.

Goodrich Announces Changes

Changes in the executive organization of the industrial products sales division of The B. F. Goodrich Company include:

Orno B. Roberts, manager of the division's Chicago district for 14 years, retired because of health, succeeded by John S. Gulledge, manager of Cincinnati district. George W. Green named manager of manufacturers' sales of industrial products, Chicago district. Ernest E. Haupt succeeds Gulledge as Cincinnati district manager.

Robert T. Kain, manager of industrial products district, San Francisco, transferred to Dallas as manager of that district succeeding David R. Anderson, assigned to special sales duties. Harland B. Lane named manager of San Francisco district.

District Sales Managers Named by General Electric

William B. Frackleton has been named district sales manager of the central (Chicago) district and Andrew Westhead sales manager of the New England (Boston) district for General Electric's chemical department. Frackleton has been in Chicago as district specialist in industrial electronic control since 1934 and Westhead formerly was in charge of the department's Springfield, Mass., sales office.

Koenitzer Named Assistant Engineer by Brown Fintube

Brown Fintube Company, Elyria, Ohio, has appointed Rolland D. Koenitzer as assistant chief engineer of the heat transfer department. In this new assignment, Koenitzer will work principally on Brown Fintube lube oil coolers, fuel oil heaters, tank heaters and compressed gas heaters and coolers.

Koenitzer

Since his graduation in engineering from Iowa State College, Koenitzer has served successively as sales engineer, project engineer, experimental engineer and chief engineer for various concerns, and most recently was assistant chief engineer of The McCord Corp., Detroit.

U. S. Motors Doubles Plant

The largest expansion in the history of U. S. Electrical Motors, Inc., is taking shape in Milford, Conn., where the company's Atlantic plant is being more than doubled in size. Completion is scheduled in June. The original plant was constructed in 1939 and was expected to be adequate for at least two decades.

The plant will be steel construction monitor type, complete with latest type lighting, cranes, conveyors, and machine tools, and with the new foundry and auxiliary buildings will add 75,000 square feet area.

With completion of the expansion program, U. S. Motors will manufacture motors used east of the Mississippi River in the Milford plant.

Grimshaw to Be Consultant

George E. Grimshaw, manager industrial insulation department, Johns-Manville Corporation, will retire from the company on April 1 to establish himself as industrial insulation consultant for the oil, steel and chemical industries with offices in New York. Grimshaw, in his 32-year association with Johns-Manville, has headquartered in Pittsburgh, Cleveland and New York.

Bigelow-Liptak Appointments

Art Brooks has joined Bigelow-Liptak Corporation, Detroit, as advertising and sales promotion manager. Prior to

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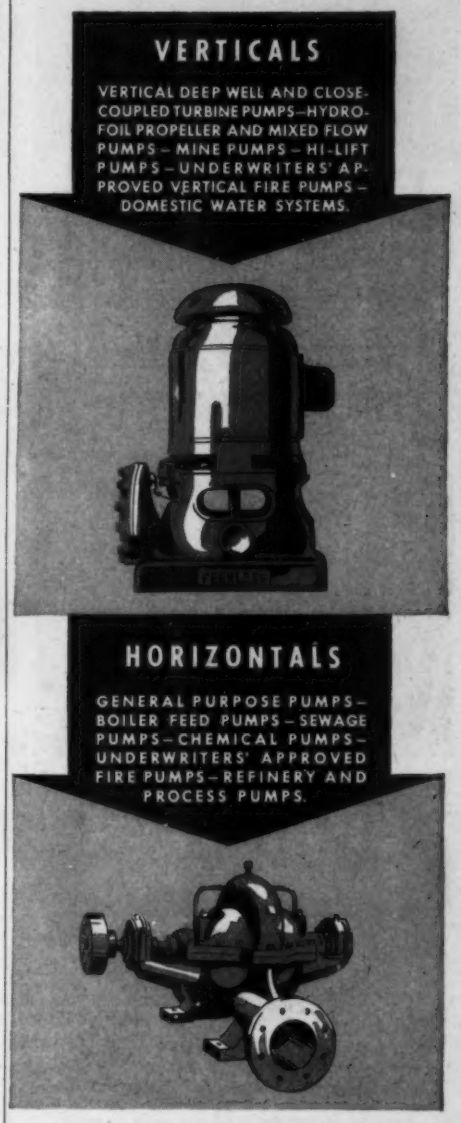
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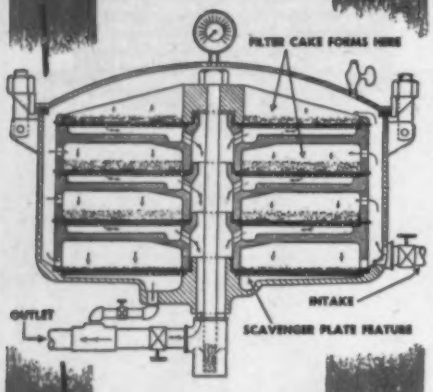

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MUNDELEIN, ILLINOIS

this appointment Brooks was account executive and copywriter for two Detroit agencies.

Bigelow-Liptak has appointed Newell Royall as its sole representative in Texas. He will maintain offices in Houston. Previously he was with Royall Fire Brick & Supply Company.

Hooker Names Klaussen

Bjarne Klaussen has been promoted to vice president in charge of production of the Hooker Electrochemical Company, Niagara Falls, New York.

Klaussen

Klaussen, a graduate of the University of Oslo, has been a member of the Hooker organization since 1916. He has been works manager of the Niagara plant since 1940 and a member of the company's board of directors since 1942.

Parker Appoints Distributor

Appointment of Standard Brass & Manufacturing Company, Beaumont, Texas, as distributor for The Parker Appliance Company, Cleveland, has been announced. Standard Brass will handle the complete line of Parker tube fittings, valves and accessories for hydraulic and fluid-handling systems, with many parts stocked at Beaumont.

General Controls Names Three

General Controls, Company, Glendale, Calif., has appointed C. G. McCarthy as its Detroit factory branch manager.

Other appointments by the company include Don S. Bentley, factory branch manager of the Los Angeles branch and F. E. Weldon as factory branch manager of the New York office.

Koppers Adopts Benefit Plan

A retirement benefit plan applicable to all hourly paid employes who reach age 65 and have been with the company 15 years or more has been announced by Koppers Company, Inc., Pittsburgh.

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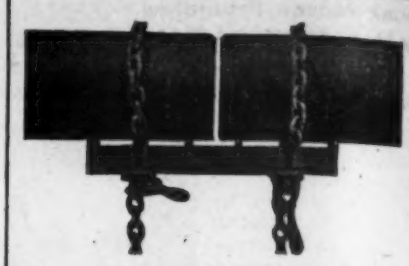
PIPE GRINDING MACHINE designed and built to give pipe line contractors maximum service in polishing the bevel on plain end pipe in preparation for welding. The machine can be placed on pipe easily and quickly, and will clean the bevel on 24-inch pipe in 15 seconds, whereas a man with file would have to work at least 15 minutes. The grinder is constructed for durability, light weight, effectiveness and economy. Electrically driven, it may be operated from electric welding machines on the line.

The Machine was perfected, and now being manufactured by Wichita Tool Repair Co., of Wichita Falls, Texas, under License from O. R. Hall, Inventor.



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E. E. Smith, J. R. Boax Given Promotions by National Tube

Appointment of E. E. Smith as manager of sales of National Tube Company for the Southwestern area, with offices at Dallas, was announced.

Smith will have general supervision over these five divisions—Dallas, Denver, Tulsa, Houston and New Orleans.

Also announced was the appointment of James R. Boax as manager of sales at Houston, succeeding Smith.

A graduate of Carnegie Institute of Technology, Smith spent several years in the engineering and operating departments of the company's National Works at McKeesport, Penn., before going to Texas as a field engineer in 1929. He was made made manager of sales at

Smith

Boax

Tulsa in 1943, and went to Houston in the same capacity last year.

Boax is a graduate of Syracuse University and has had 17 years' experience with National Tube and Oil Well Supply Company.

Allis-Chalmers Changes Involve Carden and Smith

George H. Carden and T. G. Smith have been named respectively manager of the Allis-Chalmers Baltimore district office and resident representative at Beaumont, Texas. Carden has been Washington district office sales representative since 1943 while Smith was formerly sales representative in the company's New Orleans office.

Armstrong Names Conrad To Succeed Henry Boettcher

Charles S. Conrad, Jr., has been appointed chief architect of Armstrong Cork Company, filling the vacancy created by retirement of Henry Boettcher, after 40 years' service with the company.

Conrad's former position of assistant chief architect will be filled by Floyd S. Kline.

Bird to Shreveport

C. W. Bird, formerly service engineer, New England territory, has been transferred to Shreveport, La., where he will be in charge of sales and service for the Louisiana, East Texas and South Arkansas area of The Bird-Archer Company, water conditioning engineers.

Continental Can Appointee

John S. Devlin, formerly with the War Assets Administration and before that operations engineer in the Far East for Standard-Vacuum Oil Company, has been appointed product sales manager for steel containers, Continental Can Company. He will headquarter in New York.

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